HILO AREA
COMPREHENSIVE STUDY

Hilo Harbor

SURVEY REPORT AND
FINAL ENVIRONMENTAL
IMPACT STATEMENT

REVISED APRIL 1983

US Army Corps
of Engineers
Honolulu District

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858

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HILO HARBOR, HAWAII

A SURVEY REPORT AND FINAL ENVIRONMENTAL IMPACT STATEMENT

FOR

DEEP-DRAFT NAVIGATION IMPROVEMENTS

FEBRUARY 1982
REVISED APRIL 1983

PACIFIC OCEAN DIVISION

SYLLABUS

This is a survey report of the feasibility of improving the existing Federal project at Hilo Harbor, Hawaii. The initial requests for this study were Resolutions 144 (1973) and 480 (1975) by the Hawaii County Council. In 1976, the US Congress authorized the study. The Honolulu Engineer District initiated the Hilo Area Comprehensive Study that year.

This report addresses the Deep-Draft Navigation component of the Comprehensive Study. Later reports will deal with Bay Water Quality; Small Craft Facilities; Shore Protection; Floodplain Management; Recreation and Fish and Wildlife; and Water Supply.

The existing Federal project, a 35-foot-deep harbor and a 10,080-foot-long breakwater, was completed in 1930. Since then, Hilo and the economy and population of the County of Hawaii (Hawaii Island) have grown considerably. Some improvements to Hilo Harbor are required to support the economy of Hawaii County.

The recommendations of this report are to deepen Hilo Harbor's entrance channel to 39 feet and turning basin to 38 feet to accommodate larger vessels. The total first cost of this project would be $3.7 million. Dredge material would be disposed of in deep ocean water. There are no significant adverse environmental or social effects from the implementation of this plan.

HILO HARBOR, HAWAII

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FOR

DEEP-DRAFT NAVIGATION IMPROVEMENTS

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont)

LIST OF FIGURES

LIST OF TABLES

AUTHORITY

The authority for this interim survey report is Section 144 of the Water Resources Development Act of 1976 (Public Law 94-587). Section 144 states:

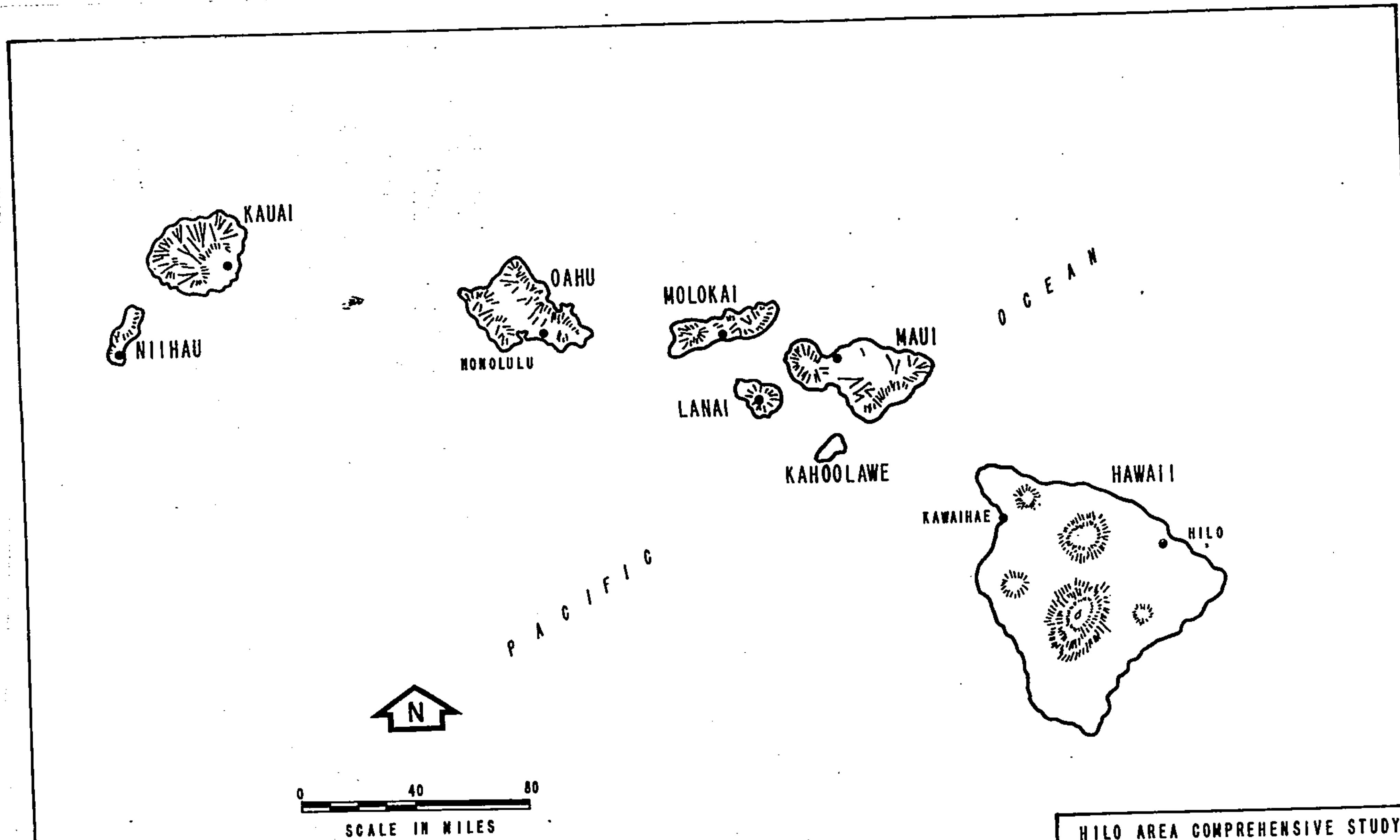
> The Secretary of the Army, acting through the Chief of Engineers, in cooperation with the State of Hawaii and appropriate units of local government, shall make a study of methods to develop, utilize, and conserve water and land resources in the Hilo Bay Area, Hawaii, and Kailua-Kona, Hawaii. Such study shall include, but not be limited to, consideration of the need for flood protection, appropriate use of flood plain lands, navigation facilities, hydro-electric power generation, regional water supply and wastewater management facilities systems, recreational facilities, enhancement and conservation of water quality, enhancement and conservation of fish and wildlife, other measures for environmental enhancement, and economic and human resources development. Based upon the findings of such study, the Secretary of the Army, acting through the Chief of Engineers, shall prepare a plan for the implementation of such findings which shall be compatible with other comprehensive development plans prepared by local planning agencies and other interested Federal agencies.

PURPOSE AND SCOPE

This report presents a plan for the implementation of the study findings to develop, utilize and conserve deep-draft navigation facilities at Hilo, Hawaii (Figure 1). This is an interim survey report which addresses deep-draft navigation issues of the study authority, and is part of the Hilo Area Comprehensive Study. Other components of the Study will be reported later.

The use of an interim report on the Comprehensive Study permits early action on significant study findings pertaining to navigation needs. The recommendations in this report are consonant with study findings pertaining to Hilo Bay's water quality and biological resources.

The investigations described in this report encompass Hilo Harbor (Figure 2). Investigations were made of the immediate and future regional needs for expansion of deep-draft navigation facilities; measures or combinations thereof capable of satisfying such needs; the accompanying economic, environmental, and social considerations; and coordination with concerned agencies and the public. These studies provide the depth and detail required to determine plan feasibility.

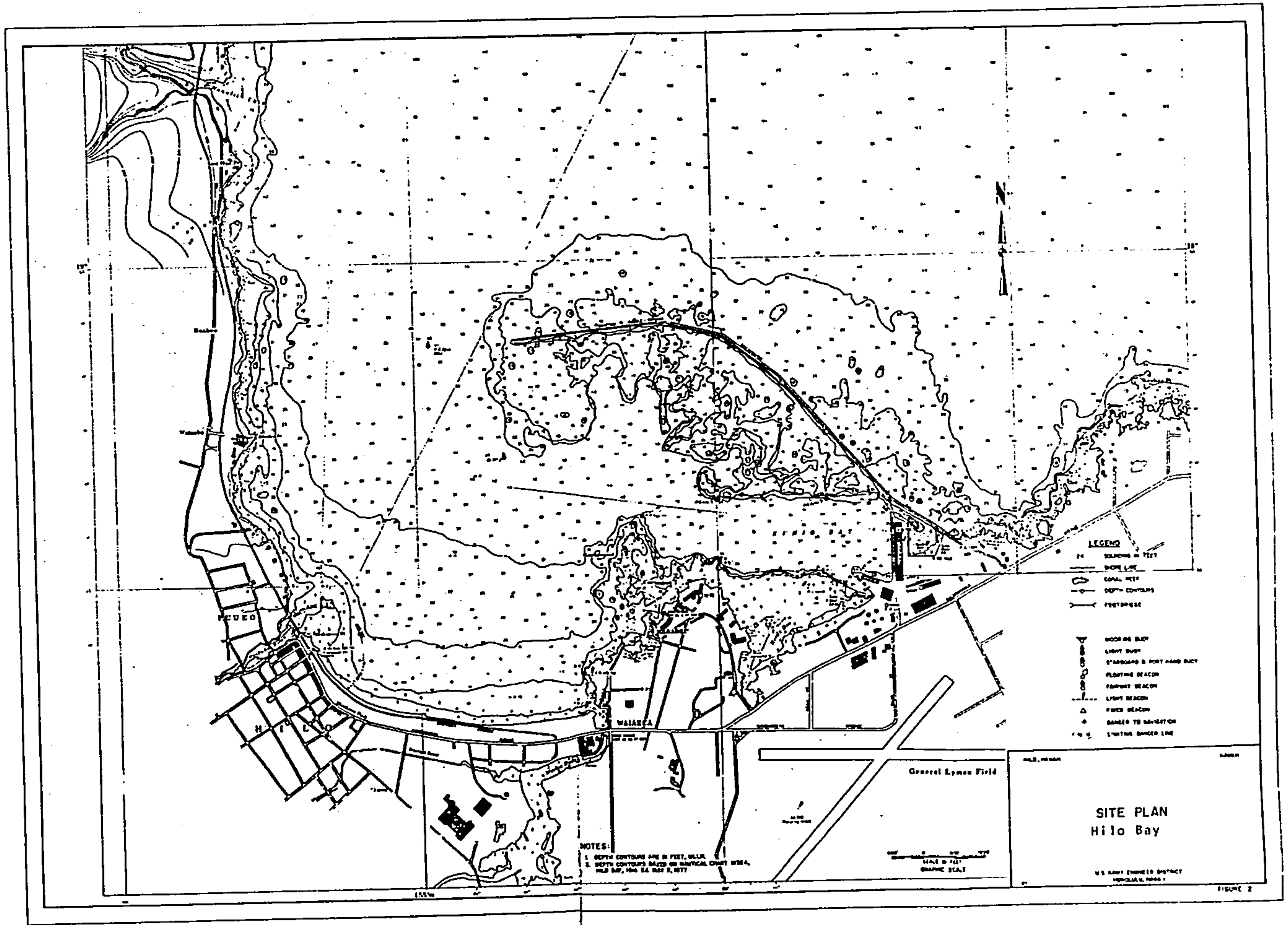


HILO AREA COMPREHENSIVE STUDY

VICINITY MAP

U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE [illegible]


N
PUEO
HILO
WAIAKEA
General Lyman Field
LEGEND
CORAL REEF
DEPTH CONTOURS
LIGHT BUOY
FLOATING BEACON
LIGHT BEACON
FIXED BEACON
NOTES:
SITE PLAN
Hilo Bay
GRAPHIC SCALE
FIGURE 2

After review and approval by the Board of Engineers for Rivers and Harbors, the final report of the Chief of Engineers will be forwarded to the Secretary of the Army. He will obtain the views of the Office of Management and Budget and transmit the report to the Congress. If the Congress concurs with the report's findings and authorizes the project, funds will be requested to perform advanced engineering and design work. After assurances of local cooperation are furnished, construction would be initiated.

This report is a decisionmaking document containing an Environmental Impact Statement. Supporting documentation including: engineering, design, and cost; and economics information is separately bound.

PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS

The existing deep-draft harbor at Hilo is an authorized project which includes a rubblemound breakwater 10,080 feet long; an entrance channel 35* feet deep; and a turning basin 1,400 feet wide, 2,300 feet long, and 35 feet deep. The project was authorized in the River and Harbor Acts of 2 March 1907, 25 July 1912, and 3 March 1925. The project was completed in July 1930. Sixty percent of the breakwater was seriously damaged during the 1946 tsunami and repairs were completed in 1948. Later breakwater repairs were completed in 1968, 1975 and 1981.

A tsunami protection project was authorized by the 1960 River and Harbor Act. A post-authorization study was completed in 1967. The study found that protective works at a cost of $60 million would be feasible. However, local government rejected the plan and its $10 million local cost-sharing requirement. The project was deauthorized in 1977.

A study to determine the feasibility of modifying Hilo Harbor to prevent surge was authorized by House Resolution 739 in 1967. The results were not fully conclusive but suggested that surge is correlated with short-period waves generated by North Pacific storms.

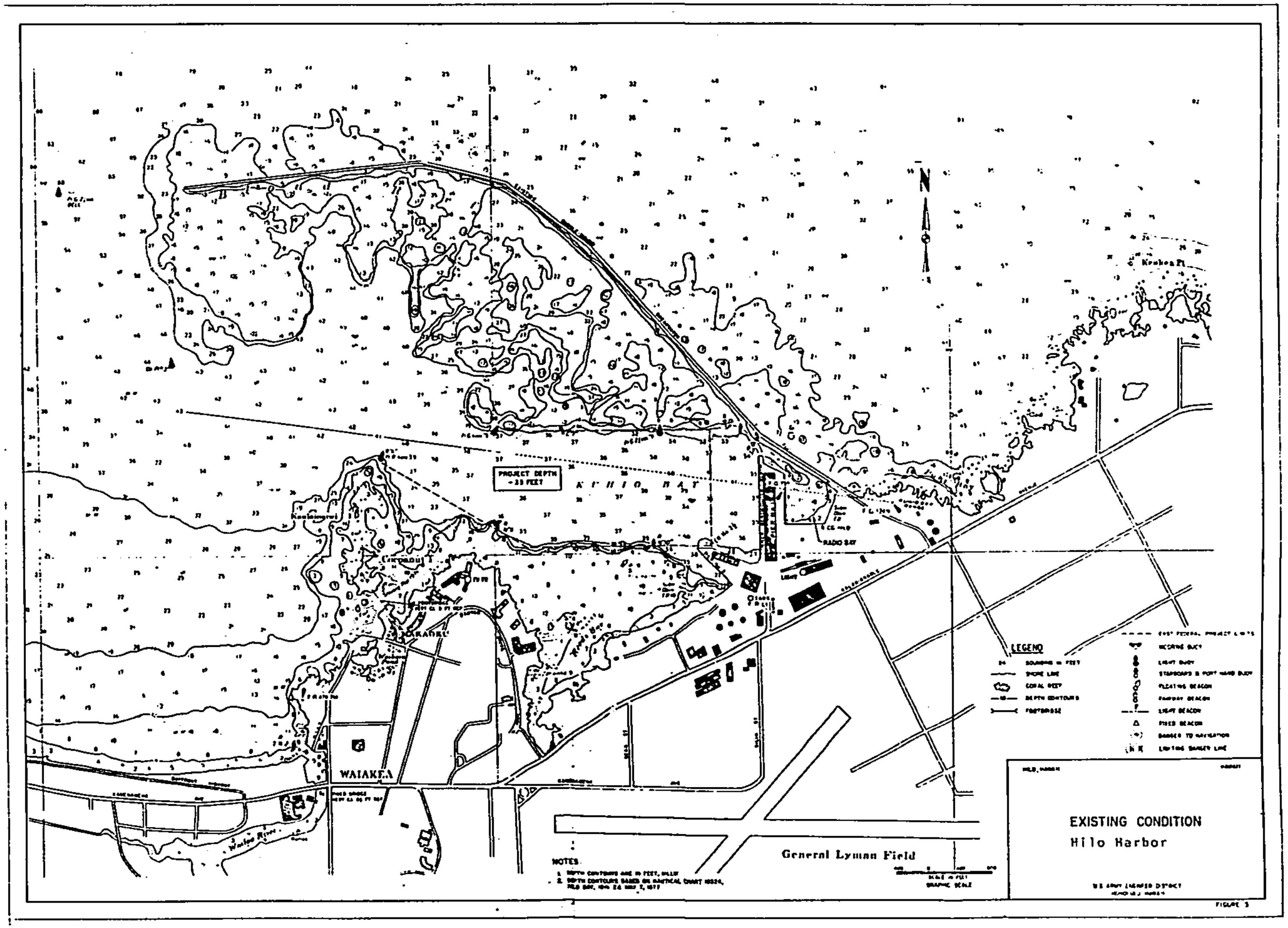
PLAN FORMULATION

Existing Conditions

Hilo is the primary commercial port of Hawaii County, an island of more than 4,000 square miles and 92,000 people. Most of the island's general cargo and petroleum inshipments and sugar and molasses outshipments pass through Hilo.

The cargo volume at the commercial port has averaged over 1 million tons annually for several years. An upward trend continues, but major increases in cargo throughput are not predicted unless significant changes to the existing economic situation develop, for example, establishment of a manganese processing industry. A passenger vessel recently began visiting Hilo and continued growth may be possible. Hilo Harbor (Figure 3) has a 35-foot project depth, which does not permit the largest capacity ships to enter or depart Hilo

*In this report, all depths are a mean lower low water datum.



N
Keokea Pt.
PROJECT DEPTH -35 FEET
KUHIO BAY
RADIO BAY
WAIAKEA
General Lyman Field
LEGEND
NOTES:
Waiakea River
EXISTING CONDITION
Hilo Harbor
FIGURE 3

Harbor fully loaded. North Pacific winter storms cause surge in the commercial port that may prevent ships from loading or unloading up to 6 days a year. This condition results in delays and damages. Although water quality has improved in recent years, the bay experiences poor circulation due to the breakwater. High turbidity occurs during heavy rainstorms and as a consequence of runoff via the Wailuku and Wailoa rivers and storm drains.

The Corps of Engineers is responsible for the maintenance of the Federal project. About 50,000 cubic yards of sediment were dredged in 1977 from the turning basin. On the breakwater, a 700-foot section directly seaward of Pier 1 was reinforced in 1981 with tribars and covered with reinforced concrete ribs at a cost of about $2 million. Additional work is expected to be done during the next few years to repair the entire breakwater, which is over 50 years old and does not meet current design criteria.

Future Conditions (Without A Project)

Longer vessels with deeper drafts (and larger cargo capacities) will replace some vessels in the existing fleet. In the absence of dredging to deepen the entrance channel and turning basin, some vessels will not be able to operate fully loaded. Some vessels will have problems turning because of the less than optimum basin width. Surge-caused ship motion at the docks will delay vessels and cause damages to lines, fenders, piers, vessels, and injury to dock workers.

Problems and Opportunities

Hilo Harbor has four main problems: (1) ship motion at the piers; (2) insufficient depth to accommodate existing and projected vessels when they are fully loaded; (3) area of the turning basin and (4) quality of the bay's water.

Ship motion at the piers is caused by surging in the bay during wave attacks which originate in the North Pacific during winter storms. Vessels are prevented from loading or unloading on an average of 6 days per year primarily during the months of October through May. Less severe surge occurs more frequently and vessel operations may be slowed or cease for short periods. There are occasional damages to piers, fenders, lines, cargo, and vessels. The risk of injury to longshoremen is serious.

The existing project was designed for smaller vessels than are used today. The project depth of the entrance channel and turning basin is 35 feet. The required underkeel clearance in the turning basin is 5 feet and in the entrance channel, 6 feet, which leaves a vessel operating draft of about 30 feet. Vessels must operate light-loaded. In addition to being economically inefficient, energy and human resources are wasted. Presently, up to 0.8 feet of tide is used by departing, loaded sugar vessels to increase their operating drafts.

The project turning basin dimensions are 1,400 feet by 2,300 feet. This is adequate for vessels up to 700 feet in length. Since the longest projected vessel is estimated at 725 feet, this would not normally be a problem. However, a mooring buoy (used to hold vessels off Pier 1 during surging conditions) is located (Figure 3) about 900 feet west of Pier 1, 600 feet north of Pier 2, and about 600 feet north of the nearest turning basin boundary. Vessels with bow thrusters are able to manuever around the buoy; vessels without bow thrusters require the assistance of two tugs. This adds to operating costs, especially since the second tug has to come from Kawaihae a distance of about 100 nautical miles. The mooring buoy is in an optimum position to hold vessels off Pier 1 during surging. The buoy, installed in 1969, partly as a response by local authorities to District suggestions, has prevented damages to the pier. Delays have been reduced because the vessels at berth can put a line to the buoy and hold off of the pier by several feet using winches. This saves costs of tug assistance and vessel start up during many surging incidents.

The quality of the bay's water responds to two variables. One is the amount of rainfall, since the major cause of high turbidity in the bay is stormwater runoff from natural and agricultural lands. The urban portion of runoff from Hilo is less than 1 percent of the bay's adjacent watershed. The second water quality variable is circulation and flushing within the bay. Hilo Harbor's long (10,080 feet) breakwater restricts circulation and is a major cause of turbidity in the bay.

Objectives

The following objectives were established for the study:

a. As a contribution to deep-draft navigation, encourage the efficient development and utilization of Hilo Harbor to accommodate all waterborne commerce and associated traffic during the 1985-2035 period of analysis.

b. Contribute to the reduction of ship delays and damages caused by ship motion or natural wave action at the Hilo docks.

Constraints

Several constraints were identified prior to formulating alternative plans.

a. Surge induced ship motion at the piers, although a problem, does not have a major effect on transportation costs at Hilo Harbor. The average annual benefits related to surge reduction are relatively small. The small size of these benefits is a planning constraint for structural remedies. Less expensive nonstructural measures of surge reduction should be implemented.

b. The relatively poor quality of Hilo Harbor sediments poses a constraint on the method of dredge spoil disposal. Land disposal is an unlikely alternative because the spoil material does not have useful properties and there are no suitable lands nearby for marshland creation.

c. The area of the turning basin is adequate but the surge-mooring buoy is a constraint. The dilemma is that if the buoy is removed to take advantage of the full turning basin, surge-caused delays and damages will increase. Conversely, leaving the surge-mooring buoy in place will cause increases in vessel operating time and tug assist costs.

ALTERNATIVES

Available Measures

The following measures are available to meet the planning objectives:

Nonstructural

Nonstructural measures include replacing the existing mooring buoy with a submersible mooring buoy, improving the existing dock fender system, installing pretensioning devices, managing vessel schedules more efficiently and developing new systems to meet the increased container storage needs.

Submersible Mooring Buoy. Persons knowledgeable of navigation and shipping conditions in Hilo Harbor agree that the buoy is invaluable during the winter months to settle ships, but at its present location, the existing mooring buoy interferes with large vessels turning in the basin. Without the buoy, ships would have to clear berth and move to an anchorage outside the harbor and perhaps not return to complete the loading operation during periods of severe surge.

A submersible buoy would solve this problem. This measure utilizes the existing anchors, ground chains, and ground ring. A buoyant tube, somewhat longer than the depth of water in the vicinity of the anchors, would be attached at one end to the ground ring. The other end of the tube would be fitted with buoyancy cells and provision for attaching ship lines. The tube serves as a tension rod link between the ship lines and existing anchors, as well as a boom which can be raised to expose the tip to which ship lines are attached. The tube and cells would be installed to not decrease project depths.

When anchorage is needed during surge conditions, high pressure air would be introduced into the air sacs in the cell and tube, displacing and thereby expelling water, such that the attachment tip of the tube is buoyed to the surface, much like a submarine surfaces upon blowing its tanks. The ship lines would then be secured to the top of the tube.

When no longer needed, the ship lines would be disconnected and the tube laid on the harbor bottom by releasing the air pressure, thereby collapsing the air sacs and flooding the tube. As a precautionary measure, hazard buoys would be placed about the tube location prior to raising the tube.

Improvements to Existing Fender System. Ship motions, as well as mooring downtime, can be reduced if breast lines of the ships are pretensioned. The steady force created by the cable pretension can hold the hull in contact with the fender system. Because of this effect, ship motions can be damped out by the friction force on the contact surface and the bumping force against the fender can partially be cancelled by the steady slide force. Monitoring the mooring lines tension and relative movement of the loading equipment is an available measure to reduce ship motion.

If pretension devices (constant tension mooring winches) are used, the assumption is that two are installed at the bow and two installed at the aft of the design vessel. Pier 1 would be top priority for fender improvement. About 1,300 lineal feet are required. Both the pretension devices and the improved dock fender system are locally implementable. Many of the vessels using Hilo Harbor have the winches but they are not used because of the existing fender design.

Other Measures. To reduce the effect of surge, one measure is management of vessel schedules. The harbor master now manages schedules, but the randomness of surge events inevitably disrupts traffic. There is no early warning of surge and some vessels' schedules vary--particularly the double tow tug and barges from the west coast. Their arrival time is not predictable to the nearest day as in the case of the container ships. Therefore, more intense management of vessel schedules is not possible nor is this an available measure.

New systems could be developed to meet container storage needs. These include stacking of containers and better utilization of the open space on the piers. This measure could be studied further by the local government.

Structural

Structural measures applicable to deep-draft navigation are dredging of a deeper entrance channel and turning basin, dredging of a wider turning basin, constructing new piers and supporting facilities to accommodate the increasing number of vessels using Hilo Harbor, constructing a revetted fill area to store additional containers, and partially removing the existing breakwater and replacing it with a new inner breakwater.

Entrance Channel and Turning Basin. In order to accommodate the larger vessels using and projected to use Hilo Harbor, the entrance channel and turning basin must be dredged to provide 6 feet underkeel clearance in the entrance channel and 5 feet in the turning basin. The one-way entrance channel width of 450 feet and depth of 39.0 feet are required to insure safe and economic navigation.

The width of the turning basin is related to ship motion at Hilo docks. Minimization of ship motion would permit removal of the buoy which is now required for ships moored during severe surge conditions. This buoy interferes with vessels turning in the basin. Removing this buoy directly affects the amount of widening that must be done to the basin to make it adequate from an operational viewpoint. With the buoy, the harbor's turning basin should be widened by 400 feet, but without the buoy the widening would not be required.

All material to be dredged is clay and silt, and deep ocean disposal is less costly and is the preferred method of disposal. Based on a strict comparison of transport costs, land disposal is least expensive where the land disposal site is less than 4.5 miles from the dredge site. However, there are no publically acceptable sites. Ocean disposal would be made at an EPA-approved site.

Additional Storage Area. Construction of a revetted fill area for additional container storage would require a quarry stone revetment to retain dredged material. The revetment would require quarry stones placed on a 1.5 horizontal to 1 vertical slope, a slope sufficiently flat to adequately dissipate wave energy. In addition, voids between stones would also provide dampening capacity to absorb wave energy, which if reflected back into the harbor, would adversely affect navigation. As a Federal project, construction of a revetted fill area is economically infeasible, but such a project could be implemented locally. It was evaluated if dredge spoil could be placed as fill. However, since the Hilo Harbor sediments are silts and clays, unsuited for fill, this alternative measure is not feasible.

Inner Harbor Protective Breakwater. This concept consists of two rubblemound breakwaters placed to reduce surge in the berthing area and would be a major structural addition to Hilo Harbor.

Development of Alternative Plans

Three preliminary plans were formulated using various combinations of the available measures shown in Table 1.

Description of Plans. Plans A (Figure 4) includes the construction of two rubblemound breakwaters (crest elevation 9.5 feet and 900 feet and 2100 feet long), an entrance channel 39 feet deep, 2200 feet long and 440 feet wide, and a turning basin 38 feet deep and 1800 feet long by 1400 feet wide.

Plan B (Figure 5), proposed by the Hawaii Island Chamber of Commerce, requires breakwater modifications, construction of new fill, roads and revetments for 100 acres of fast land. The entrance channel and turning basin would be deepened as in Plan A.

Plan C (Figure 6) includes the project deepening as in Plan A.

Screening of Alternatives

The three plans formulated in preliminary planning were carried forward for screening. The plans vary considerably in their costs, structural and nonstructural features, and environmental impacts. The plans are identified as follows:

Plan A - Inner Harbor Protective Breakwater and Deepening.

Plan B - Chamber of Commerce Plan.

Plan C - Harbor Deepening and Nonstructural Measures.

The cost apportionment for each plan is based on current law and regulations. Revisions in cost apportionment policy are discussed in the section "PLAN IMPLEMENTATION."

TABLE 1. AVAILABLE MEASURES

Planning Objective	Management Measure	Planning Status
As a contribution to deep-draft navigation, encourage the efficient development & utilization of Hilo Harbor to accommodate all water-borne commerce and associated traffic during the 1985-2035 period of analysis.	Dredge a deeper entrance channel & turning basin.	Included in Plans A, B, C.
	Dredge a wider turning basin.	Submersible mooring buoy is more favorable.
	Remove existing mooring buoy & replace with submersible mooring buoy.	Locally implementable.
	Construct a revetted fill area to store additional containers.	Economically infeasible for Federal project. May be locally implementable.
	Stack containers on existing storage area.	Locally implementable.
	Adjust vessel schedules.	Locally implementable.
	Reduce time to tie-up and turn.	Locally implementable.
	Build new piers and supporting facilities.	Locally implementable.
Contribute to the reduction of ship delays and damages caused by ship motion or natural wave action at the Hilo docks.	Improve ship fender system.	Locally implementable.
	Manage vessel schedules more efficiently.	Currently implemented.
	Install pretension winches.	Partially implemented by local interests.
	Construct an inner breakwater to provide greater protection to the port.	Included in Plan A.

PLAN A - INNER HARBOR PROTECTIVE BREAKWATERS AND DEEPENING

Description. This plan (Figure 4) requires construction of two rubblemound breakwaters to minimize wave energy entering the berthing areas. Deepening of the entrance channel to 39 feet and turning basin to 38 feet are also included in this plan. Table 2 shows the construction costs of this plan.

TABLE 2. PLAN A COSTS AND BENEFITS ($)

Project First Cost	$20,200,000
Engineering, Design, Supervision & Administration (E&D,S&A)	1,600,000
Interest During Construction (IDC) 24-month Construction Period	1,717,000
Total Investment Cost	$23,517,000
Interest & Amortization (.08057 or 7-7/8%) on the Total Investment Cost	1,895,000
Annual Operation & Maintenance (O&M) Cost	45,000
Total Average Annual Cost	$1,940,000
Average Annual Benefits	$ 791,000
Benefit-Cost Ratio	0.4
Net NED Benefits	NONE

COST APPORTIONMENT	NON-FEDERAL	FEDERAL
Project First Cost	$322,000	$19,878,000
E&D, S&A	50,000	1,550,000
IDC		1,717,000
Total Investment Cost	$372,000	$23,145,000
Average Annual Costs	$ 30,000	$ 1,910,000

Impact Assessment. Enclosing the inner harbor will reduce wave energy and mixing of the water layers and reduce water exchange with the outer harbor. There would be a decrease in bay water quality. Deepening will temporarily increase water turbidity.

Mitigation Requirements. None.

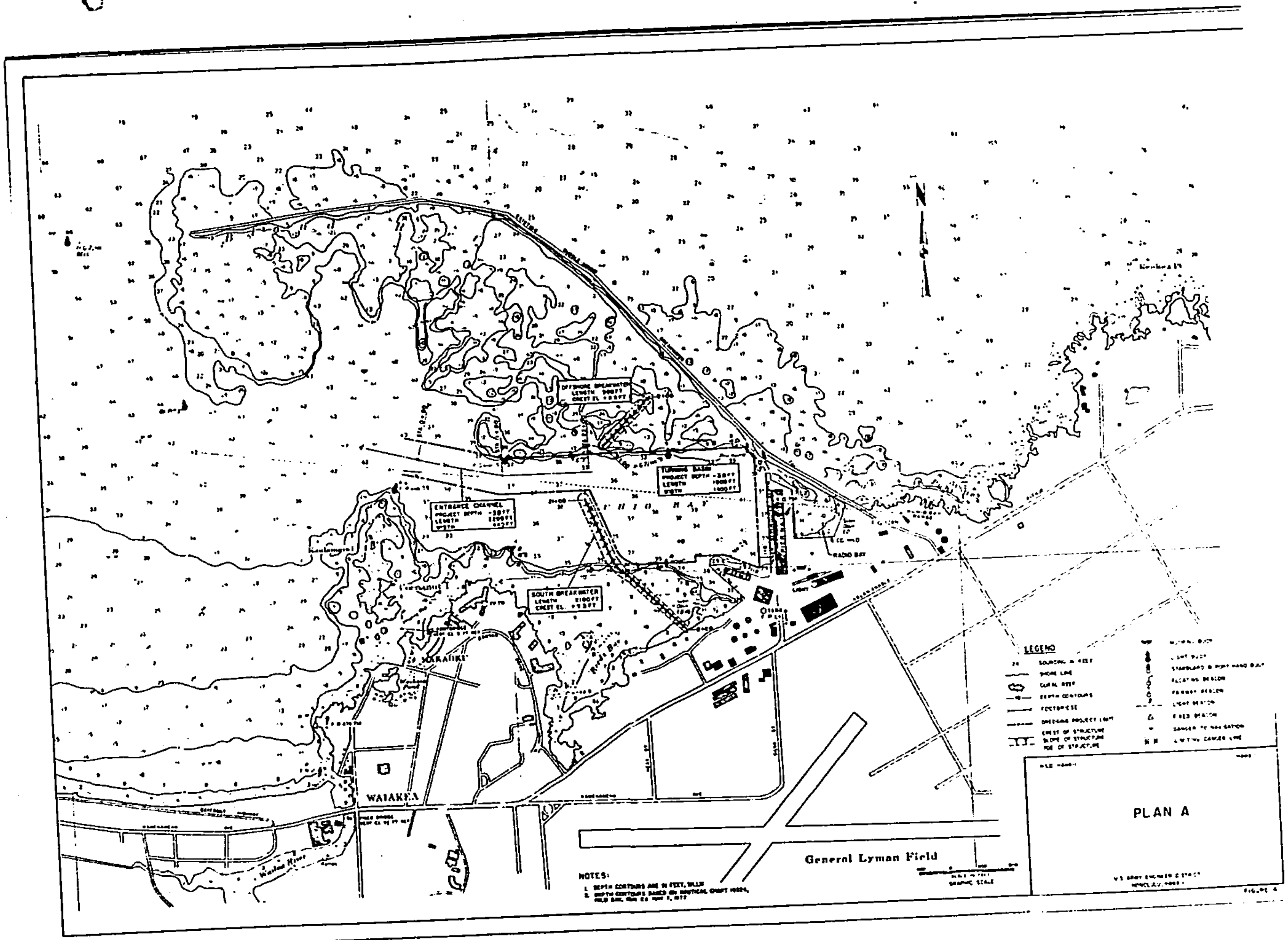
Implementation Responsibilities. The Corps would provide overall management for implementation and the State would be responsible for all local requirements.

Cost Allocation. None.

Public Views.

Federal Agencies. The USF&WS would prefer to improve, not decrease circulation in the harbor.

Non-Federal Agencies. No objections.


N
ENTRANCE CHANNEL
PROJECT DEPTH
LENGTH
WIDTH
OFFSHORE BREAKWATER
LENGTH
CREST EL.
TURNING BASIN
PROJECT DEPTH
LENGTH
WIDTH
SOUTH BREAKWATER
LENGTH
CREST EL.
RADIO BAY
WAIAKEA
General Lyman Field
NOTES:
LEGEND
SHORE LINE
DEPTH CONTOURS
CREST OF STRUCTURE
SLOPE OF STRUCTURE
TOE OF STRUCTURE
PLAN A

PLAN B - CHAMBER OF COMMERCE PLAN

Description. This plan (Figure 5) requires extensive breakwater modifications, construction, dredging and filling. It would provide new land for harbor operations and additional piers. Table 3 displays the costs.

TABLE 3. PLAN B COSTS & BENEFITS ($)

Project First Cost	$116,911,000
Engineering, Design, Supervision & Administration (E&D,S&A)	7,115,000
Interest During Construction (IDC) 36-month Construction Period	14,651,000
Total Investment Cost	$138,677,000
Interest & Amortization (.08057 or 7-7/8%) on the Total Investment Cost	11,173,000
Annual Operation & Maintenance (O&M) Cost	44,000
Total Average Annual Cost	$11,217,000
Average Annual Benefits	$627,000
Benefit-Cost Ratio	0.1
Net NED Benefits	NONE

COST APPORTIONMENT	NON-FEDERAL	FEDERAL
Project First Cost	$72,904,000	$44,007,000
E&D, S&A	4,411,000	2,703,000
IDC		14,651,000
Total Investment Cost	$77,315,000	$61,361,000
Average Annual Costs	$6,229,000	$4,944,000

Impact Assessment. This plan would eliminate much of Blonde Reef, the most extensive coral habitat in Hilo Bay due to filling and dredging. Temporary impacts on water turbidity and sedimentation are anticipated. The historic Hilo breakwater would be realigned.

Mitigation Requirements. Mitigation could be required due to the loss of Blonde Reef.

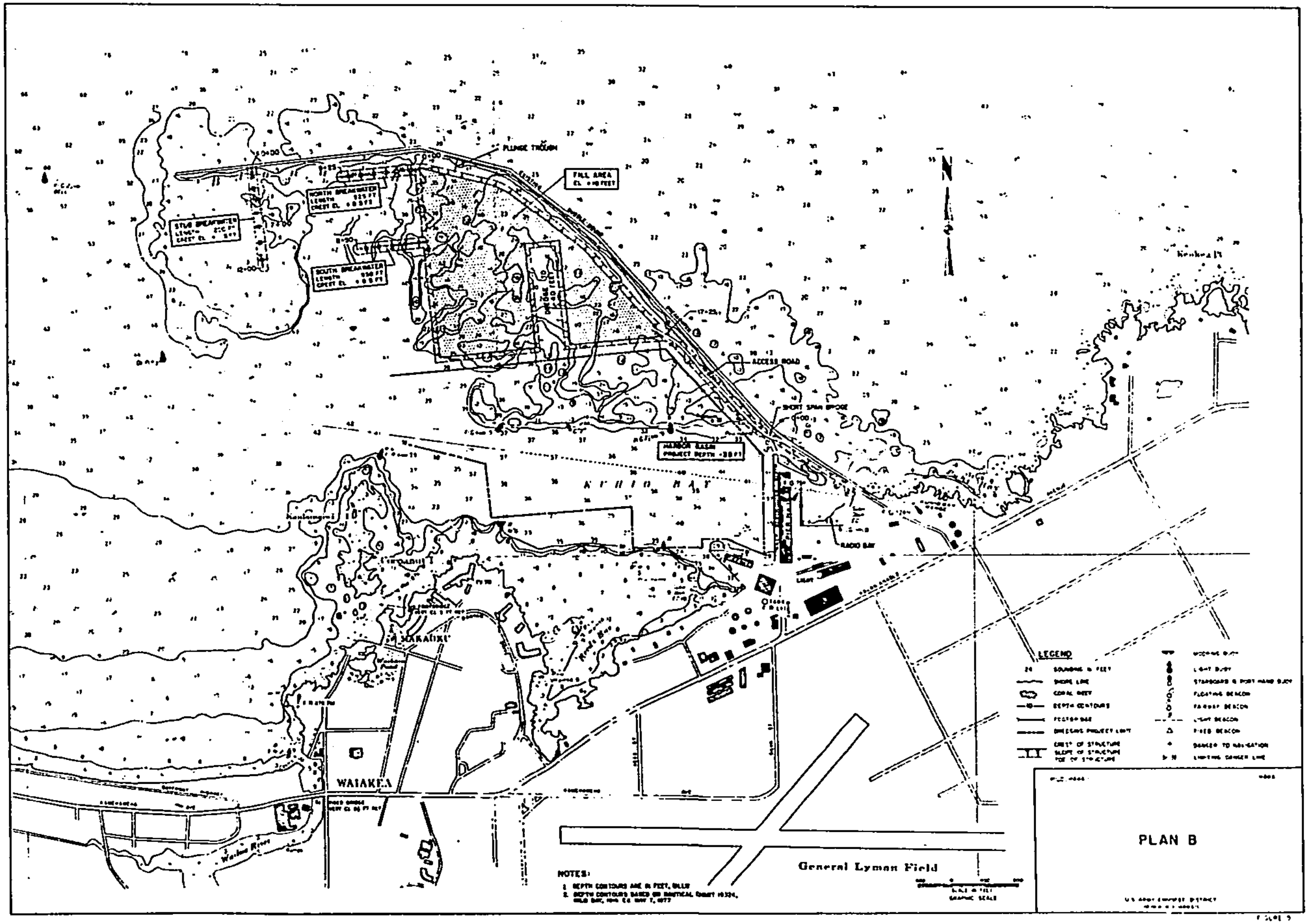
Implementation Responsibilities. The Corps would provide overall management for implementation and the State would be responsible for all local requirements.

Cost Allocation. None.

Public Views.

Federal Agencies: The USF&WS opposes this plan.

Non-Federal Agencies: The Hilo Chamber of Commerce suggested and supports this plan.



PLUNGE TROUGH
FILL AREA
NORTH BREAKWATER
SOUTH BREAKWATER
STUB BREAKWATER
ACCESS ROAD
SHORT SPAN BRIDGE
HARBOR BASIN
RADIO BAY
KUHIO BAY
WAIAKEA
General Lyman Field
LEGEND
NOTES:
PLAN B

PLAN C - HARBOR DEEPENING AND NON STRUCTURAL MEASURES

Description. This plan (Figure 6) would deepen the entrance channel to 39 feet and the turning basin to 38 feet. Table 4 displays the construction and maintenance costs for Plan D.

TABLE 4. PLAN C COSTS & BENEFITS ($)

Project First Cost	$3,081,000
Engineering, Design, Supervision & Administration (E&D,S&A)	580,000
Interest During Construction (IDC) 12-month Construction Period	144,000
Total Investment Cost	$3,805,000
Interest & Amortization (.08057 or 7-7/8%) on the Total Investment Cost	$307,000
Annual Operation & Maintenance (O&M) Cost	-
Total Average Annual Cost	$307,000
Average Annual Benefits	$627,000
Benefit-Cost Ratio	2.0
Net NED Benefits	$320,000

COST APPORTIONMENT	NON-FEDERAL	FEDERAL
Project First Cost	$261,000	$2,820,000
E&D, S&A	50,000	530,000
IDC		144,000
Total Investment Cost	$311,000	$3,494,000
Average Annual Costs	$25,000	$282,000

Impact Assessment. There would be temporary impacts on water quality in the bay associated with dredging. No significant impacts due to construction of the mooring buoy anticipated. No effect on the historic Hilo breakwater is anticipated.

Mitigation Requirements. None.

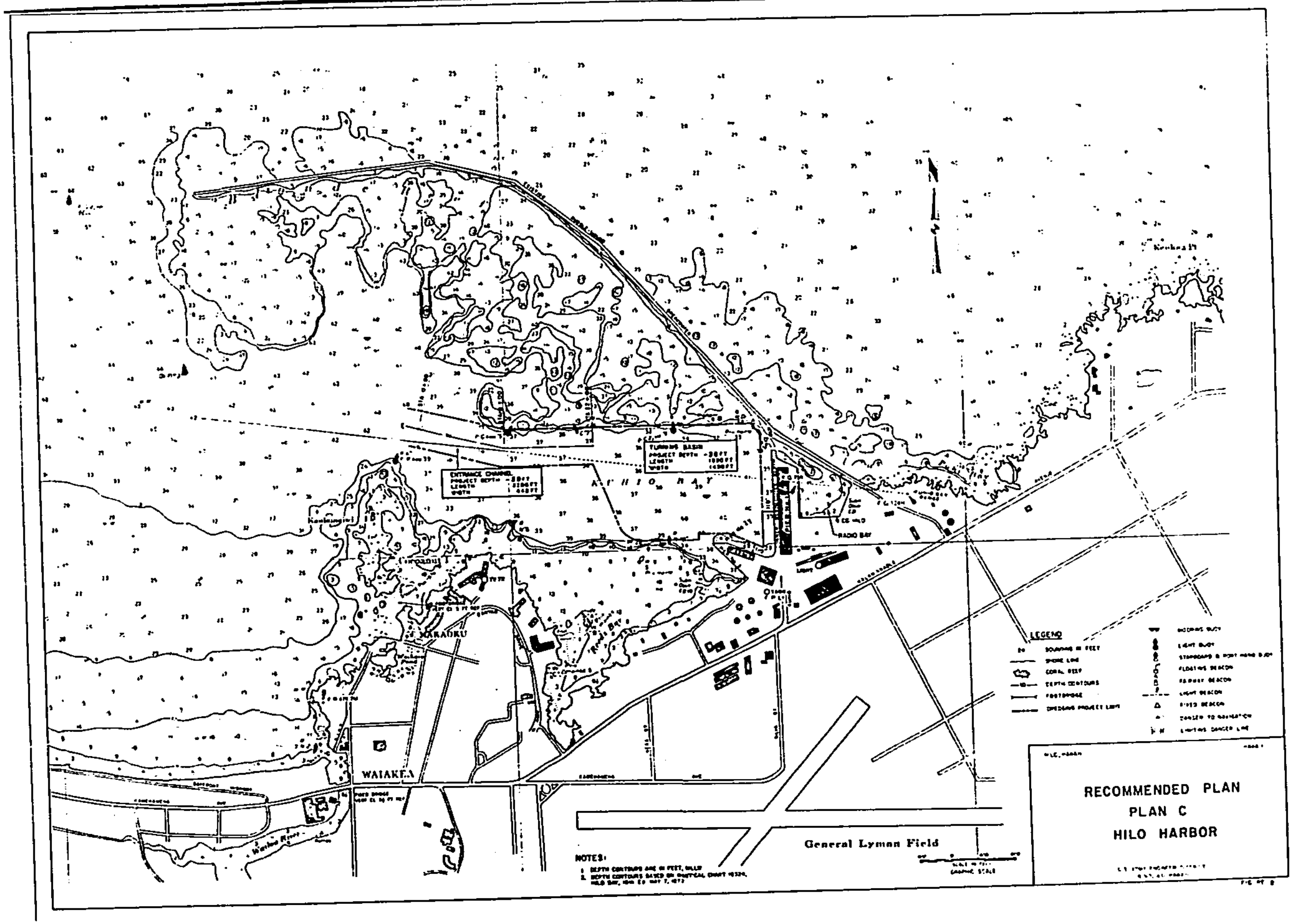
Implementation Responsibilities. The Corps would provide overall management for implementation and the State would be responsible for all local requirements.

Cost Allocation. None.

Public Views.

Federal Agencies: This plan is acceptable to the USF&WS.

Non-Federal Agencies: This plan is acceptable to local agencies.



RECOMMENDED PLAN
PLAN C
HILO HARBOR
General Lyman Field
WAIAKEA
RADIO BAY
ENTRANCE CHANNEL
TURNING BASIN
LEGEND
NOTES:

EVALUATION OF FINAL PLANS

PLAN A - INNER HARBOR PROTECTION (Figure 4). This plan has a benefit-to-cost ratio less than unity (BCR = 0.4). It should reduce surge. It would worsen the environmental conditions in inner Hilo Harbor. Deepening is included so that deeper draft vessels could be accommodated.

PLAN B - CHAMBER OF COMMERCE PLAN (Figure 5). This plan has a benefit-to-cost ratio less than unity (BCR = 0.1). The plan would have significant negative impacts on the natural marine environment. Deeper draft vessels would be accommodated. The plan would provide benefits to local interests because of the opportunities for growth.

PLAN C - HARBOR DEEPENING AND NONSTRUCTURAL MEASURES (Figure 6). This plan has a benefit-to-cost ratio greater than unity (BCR = 2.0). Deeper draft vessels would be accommodated through dredging.

Table 5 shows a breakdown of the benefits attributed to each of the three plans. The computations are based on a 7-7/8 percent interest rate and a 50-year project life. The project base year 1985 is when benefits are expected to begin accruing.

TABLE 5. COMPARISON OF AVERAGE ANNUAL BENEFITS ($)

Benefit	Plan A	Plan B	Plan C
Increased Channel Depth	$627,000	$627,000	$627,000
Savings in Delays and Damages	164,000	-	-
TOTAL AVERAGE ANNUAL BENEFITS	$791,000	$627,000	$627,000

Costs for construction were estimated at October 1982 price levels. Table 6 shows summary of costs and benefits for the four alternative plans.

TABLE 6. SUMMARY OF COSTS AND BENEFITS ($)

	Plan A	Plan B	Plan C
Total Investment Cost	$23,517,000	$138,677,000	$3,805,000
Federal Share	23,145,000	61,361,000	3,494,000
Non-Federal Share	372,000	77,315,000	311,000
Average Annual Costs	1,940,000	11,217,000	307,000
Average Annual Benefits	791,000	627,000	627,000
Net Annual NED Benefits	NONE	NONE	320,000
Benefit-Cost Ratio	0.4	0.1	2.0

Rationale for Designation of NED Plan

Plan C has the greatest net benefits. It is the NED Plan.

TRADE-OFF ANALYSIS

Plans A and B make net deductions from the national economic development (NED) account. Plan C makes net contributions to NED.

Plans A and B were dropped from further consideration because of their lack of positive contributions to national goals.

The System of Accounts (Table 7) displays and compares the costs, benefits and impacts of each plan.

TABLE 7. SYSTEMS OF ACCOUNTS

	Without Condition	WITH CONDITION PLAN A Inner Harbor Protection	PLAN B Chamber of Commerce Plan	PLAN C Harbor Deepening
A. PLAN DESCRIPTION	Repair & maintain: 10,080-foot breakwater. 35-foot project depth.	Dredge entrance channel to 39 feet and turning basin to 38 feet.	Same.	Same.
		Maintain existing 10,080-foot breakwater.	Major modification of existing 10,080-foot breakwater to include bridge, access road to new harbor areas.	Maintain existing 10,080-foot breakwater.
		Construct 2 inner breakwaters 900 feet and 2,100 feet.	Construct revetted fills.	
B. IMPACT ASSESSMENT				
1. Social Well-Being.				
	Hilo Breakwater historic site.	Adds 2 breakwaters to the view. No adverse effect. (1, 6, 9)	Breakwater realigned as part of the project. No adverse effect. (1, 6, 9)	No effect.

TABLE 7. SYSTEMS OF ACCOUNTS (Cont)

		WITH CONDITION		
	Without Condition	PLAN A Inner Harbor Protection	PLAN B Chamber of Commerce Plan	PLAN C Harbor Deepening
2. Environmental.				
a. Marine Environment.	Silt stressed Blonde Reef, silty harbor bottom.	80 acres of silty bottom disturbed. (1, 6, 9)	80 acres of silty bottom habitat disturbed. (1, 6, 9)	80 acres of silty bottom habitat disturbed. (1, 6, 9)
		Maintenance dredging cycle increased from 10 to 15 years.		Maintenance dredging cycle increased from 10 to 15 years.
		6 acres reef habitat covered. (1, 6, 9)	240 acres of marine habitat destroyed by fill and dredging. (1, 6, 9)	
		4 acres of rocky intertidal habitat created. (1, 6, 9)	7 acres of rocky intertidal habitat created. (1, 6, 9)	
b. Terrestrial Environment.	Developed park, commercial, industrial area.	No effect.	Increased land for industrial; commercial development; 100 acres (1, 6, 9)	No effect.
c. Water Quality Degraded.	Reduced flushing, circulation, water exchange. Low mixing, riverine discharges, high turbidity and siltation.	Temporary turbidity; 90 days. (1, 6, 9)	Temporary turbidity; 90 days. (1, 6, 9)	Temporary turbidity; 90 days. (1, 6, 9)
	Existing ocean disposal site	551,000 CY ocean disposal. (1, 4, 9)	551,000 CY ocean disposal. (1, 4, 9)	551,000 CY ocean disposal. (1, 4, 9)
		No long-term water quality change.	No long-term water quality change, although greater potential for trash pollutants.	No long-term water quality change.

TABLE 7. SYSTEMS OF ACCOUNTS (Cont)

		WITH CONDITION		
	Without Condition	PLAN A Inner Harbor Protection	PLAN B Chamber of Commerce Plan	PLAN C Harbor Deepening
C. PLAN EVALUATION				
1. Contributions to Planning Objectives.				
a. Provide for deeper draft and larger vessels of the existing and future fleets.	No	Yes	Yes	Yes
b. Reduce delays & damages caused by ship motion or "surge" at the Hilo docks.	No	Yes	No	No
2. Response to Formulation Criteria.				
a. Provide a project with a benefit-to-cost ratio of 1.		No	No	Yes
b. Enhance, preserve or minimize effects on marine & terrestrial resources.		No	No	Yes

TABLE 7. SYSTEMS OF ACCOUNTS (Cont)

	Without Condition	WITH CONDITION: PLAN A Inner Harbor Protection	WITH CONDITION: PLAN B Chamber of Commerce Plan	WITH CONDITION: PLAN C Harbor Deepening
C. PLAN EVALUATION: (cont)				
3. Relationship to National Accounts.				
a. National economic development (NED):				
Avg annual benefits	NA	$ 791,000	$ 627,000	$ 627,000
Avg annual cost	NA	$1,940,000	$11,217,000	$ 307,000
Net annual benefits	NA	NONE	NONE	$ 320,000
Benefit to cost ratio	NA	0.4	0.1	2.0
b. Environmental quality (EQ).		No	No, miaximum loss of marine environment.	Yes, least amount of environmental change.
c. Regional Development (RD).		No effect.	Possible increased local development.	No effect.
d. Other Social.	Economic urban growth same as projected by state and county.	No effect.	No effect.	No effect.
4. Responses to Associated Evaluation Criteria.				
a. Acceptability.	NA	Acceptable.	Unacceptable to USF&WS. some Hilo public.	Acceptable.
b. Completeness.	NA	Incomplete.	Incomplete.	Complete.
c. Effectiveness.	NA	Ineffective.	Ineffective.	Effective.
d. Efficiency.	NA	Inefficient.	Inefficient.	Very efficient.

TABLE 7. SYSTEMS OF ACCOUNTS (Cont)

		WITH CONDITION		
	Without Condition	PLAN A Inner Harbor Protection	PLAN B Chamber of Commerce Plan	PLAN C Harbor Deepening
D. IMPLEMENTATION RESPONSIBILITIES				
1. Corps of Engineers.	NA	Construct breakwater and dredge.	Dredge.	Dredge.
2. State of Hawaii.	NA	No new requirements. O&M requirements.	Construct new piers, roads, bridge.	Dredge berthing areas.
3. U.S. Coast Guard.	NA	Additional navigational aids are required.	Additional navigational aids are required.	Relocation of channel & basin buoys required.

INDEX OF FOOTNOTES:

TIMING
1. Impact is expected to occur prior to or during implementation of the plan.
2. Impact is expected within 5 years following plan implementation.
3. Impact is expected in a longer timeframe (15 or more years following implementation).

UNCERTAINTY
4. The uncertainty associated with impact is 50 percent or more.
5. The uncertainty is between 10 percent and 50 percent.
6. The uncertainty is less than 10 percent.

EXCLUSIVITY
7. Overlapping entry: Fully monetized in NED account.
8. Overlapping entry: Not fully monetized in NED account.

ACTUALITY
9. Impact will occur with implementation.
10. Impact will occur only when specific additional actions are carried out during implementation.
11. Impact will not occur because necessary additional actions are lacking.
(*) Item specifically required in Section 122, Public Law 91-611 and ER 1195-2-240.

PLAN SELECTION

Plan C was selected as the final plan because of its low cost, ease of implementation and overall contribution to national objectives. The depth of dredging was based on the sensitivity analysis shown in Table 8.

Plan C does not have a significant effect on water quality. In public testimony and review comments, the general public and government agencies expressed favor for plans which would improve water quality. The Comprehensive Study is evaluating recommendations for improvement in water quality.

TABLE 8. SENSITIVITY ANALYSIS: INCREASED DEPTH

Depth (ft) (Basin/Channel)	Average Annual Cost ($)	Average Annual Benefit ($)	BCR	Net NED Benefits ($)	Total Investment Cost
36/37	201,000	246,000	1.2	45,000	2,497,000
37/38	249,000	438,000	1.8	189,000	3,090,000
38/39	307,000	627,000	2.0	320,000	3,805,000

SELECTED PLAN DESCRIPTION

Components

The selected plan includes the following components:

a. Deepening the entrance channel to 39 feet and the turning basin to 38 feet (Figure 6). This will provide for a vessel of 33-foot draft at MLLW and a 34-foot draft with a tide of 1.0 feet.

b. Local interests will continue their current management practices of special scheduling and handling measures during surge conditions.

Plan C's harbor lines are slightly modified from the existing project (Figure 3).

Dredge material would be disposed at an ocean site about 5 miles from Hilo. This site was approved by the U.S. Environmental Protection Agency in 1981.

Design and Construction

Design work can be accomplished in less than one year as can construction. Due to the simplicity of the selected plan, no problems are anticipated.

Operation and Maintenance

Maintenance would require about 50,000 cubic yards every 15 years to be dredged and disposed. This is the same volume as the existing project because there is no increase in the area of the project. Increases in volumes over existing conditions are not anticipated because sedimentation in the project is at a slow rate and there are no sediment sources directly to the harbor basin.

Accomplishments

The selected Plan C provides for more efficient ocean transport of cargo to and from the island of Hawaii and Hilo, its population and commercial center. Deeper draft and more fully loaded vessels would be accommodated by deepening the project.

The selected plan is in compliance with Engineer Pamphlet 1165-2-1, Section 5 in that there will be no shoreline impacts on river mouths or inlets due to the implementation of the recommended Plan C.

Summary of Economic, Environmental and Other Social Effects

SELECTED PLAN (PLAN C)

Economics

Project First Cost	$3,081,000
Engineering, Design, Supervision and Construction	580,000
TOTAL PROJECT FIRST COST	$3,661,000
Federal Share	$3,350,000
Non-Federal Share	$311,000

The average annual cost of the Federal share is $270,000 at an interest rate of 7-7/8% for a 50-year project life. Costs and benefits are at October 1982 price levels. The benefit-cost ratio is 2.0.

Environment

- Temporary turbidity during dredging.
- The harbor may have higher water quality once polluted sediments are removed.
- No significant long-term effects or changes.

Social

- Long-term benefits to the community by helping to keep lowest possible freight rates.
- No significant changes.

Table 10 follows with specific Water Resources Council designated information.

TABLE 9. EFFECTS OF THE RECOMMENDED PLAN ON RESOURCES OF PRINCIPAL NATIONAL RECOGNITION

Types of Resources	Principal Sources of National Recognition	Measurement of Effect
Air quality.	Clean Air Act.	No effect.
Areas of particular concern within the coastal zone.	Coastal Zone Management Act.	No effect.
Fish and wildlife habitat.	Fish and Wildlife Coordination Act.	No effect.
Endangered and threatened species critical habitat.	Endangered Species Act.	Resource not present in the planning area.
Floodplains.	E.O. 11988, Floodplain Management.	No effect.
Historic & cultural properties.	National Historic Preservation Act.	No effect.
Prime and unique farmland.	CEQ Memorandum of Aug 1, 1980, Analysis of Impacts on Prime or Unique Agricultural Lands in Implementing the National Environmental Policy Act.	Resource not present in the planning area.
Water quality.	Clean Water Act.	No effect.
Wetlands.	E.O. 11990, Protection of Wetlands, Clean Water Act of 1977.	No effect.
Wild and scenic rivers.	Wild and Scenic Rivers Act.	Resource not present in the planning area.

IMPLEMENTATION

Institutional Requirements

Following authorization by Congress, the Honolulu Engineer District would perform final preconstruction engineering and design work. The District would administer construction. The Division of Harbors, Department of Transportation, State of Hawaii is the local sponsor and responsible administrator for operation of Hilo Harbor.

Federal and Non-Federal Responsibilities

Under current regulations, the local share of the project requires dredging (estimated cost: $311,000) of the berthing area next to Pier 1. However, under proposals recently made by the Federal government, all Federal costs of this project would be reimbursed by the local government. This issue would be resolved prior to implementation of the project. The items of local cooperation have been discussed with the sponsor.

Upon completion of construction of the recommended plan, the new project boundary lines will take effect and the Federal government will no longer maintain areas outside those lines. See Figures 3 and 6 for the comparative boundaries.

Views of the Sponsor

The sponsor approves of the plan and has submitted a letter of intent (Figure 7).

SUMMARY OF COORDINATION, PUBLIC VIEWS AND COMMENTS

In August 1981, the District circulated the Draft Navigation Report and Draft Environmental Impact Statement for public review and comment. The report included small-craft facilities as well as deep-draft facilities. This current report has carried forward only the deep-draft portions and the small-craft facilities will be the topic of a separate report at a later date.

Public and agency comments on the deep-draft planning have found the selected plan (Plan C) acceptable. However, the public and agencies have expressed a need for improved water quality in Hilo Bay. For this reason, as noted in the previous section "PLAN FORMULATION: Selection of the Final Plan," a measure to improve water quality will be discussed in a later report of the Comprehensive Study. This report incorporates comments made at a public meeting in Hilo on 17 September 1981.

RECOMMENDATIONS

I recommend that the plan of navigation improvements in the Hilo Harbor area herein indicated as Plan C be authorized for construction with such modifications as in the discretion of the Chief of Engineers may be advisable, at a first cost to the United States of $3,350,000 and an average annual first cost of $270,000. Since the administration is reviewing project cost sharing and financing across the entire spectrum of water resource development functions and has submitted proposed legislation to Congress, I recommend project authorization subject to cost sharing and financing arrangements which are satisfactory to the President and Congress.

a. Provide without cost to the United States, all lands, easements, and rights-of-way required for construction and maintenance of the project and for aids to navigation upon request fo the Chief of Engineers, including suitable areas determined by the Chief of Engineers to be required in the general public interest for disposal of dredged material;

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION

RYOKICHI HIGASHIONNA, PhD
DIRECTOR

IN REPLY REFER TO

January 7, 1982

HAR-EP 2347

12 JAN 1982

LTC Kenneth E. Sprague
District Engineer
U. S. Army Engineer District, Honolulu
Building 230
Ft. Shafter, Hawaii 96858

Dear Colonel Sprague:

Hilo Deep-Draft Harbor

In response to your letter of November 10, 1981, the State of Hawaii, under existing laws, agrees to the following if the United States Congress authorizes construction of the recommended improvements to Hilo Harbor as described in your draft report of August, 1981:

1. Provide without cost to the United States all lands, easements, and rights-of-way necessary for the construction and subsequent maintenance of the project.

2. Provide and maintain without cost to the United States adequate public terminal and transfer facilities open to all on equal terms.

3. Maintain regulations prohibiting discharge of untreated sewage, garbage, industrial waste, and other pollutants into the water of the harbor by users, thereof, which regulations shall be in accordance with applicable laws of Federal, State, and local authorities responsible for pollution prevention and control.

4. Hold and save the United States free from damages due to the construction work other than damages due to fault or negligence of the United States or its contractors.

5. Provide and maintain, without cost to the United States, depth in berthing areas and local access channels serving the terminals commensurate with the depths to be provided as proposed in the selected plan.

The State is fully cognizant of pending Federal legislation which would require local sponsors to reimburse the Federal Government for expenditure by the U. S. Army Corps of Engineers for the construction of the navigational improvements as proposed in the selected plan. Should such legislation be adopted, we intend to evaluate the implications at the appropriate time to determine the extent to which the State can participate in the development of the project.

The proposal to deepen Hilo Harbor's turning basin will require investigating whether the existing pier can tolerate a corresponding deepening in the adjacent State's berthing area without compromising the integrity of the pier structure. We feel it would be advantageous to both our agencies if such an analysis was conducted during this early preliminary feasibility study stage.

We understand that this letter expresses the intent of the State of Hawaii and in no way legally binds us to the above agreement.

Very truly yours,

Ryokichi Higashionna

Ryokichi Higashionna
Director of Transportation

FIGURE 7

b. Provide and maintain, without cost to the United States, berthing areas with a width of not less than 110 feet measured and a depth commensurate to the adjacent channel or turning basin depth;

c. Provide and maintain, without cost to the United States, adequate additional public terminal transfer facilities, and public access to the harbor, open to all on equal terms;

d. Accomplish, without cost to the United States, such alterations and relocations as may be required for the construction works and relocation assistance and payments in compliance with the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646;

e. Hold and save the United States free from damages due to the construction works, excluding damages due to the fault or negligence of the United States or its contractors;

f. Prohibit erection of any structure within 110 feet of the bottom edge of any proposed channel or turning basin;

DATE: 83 July 12

ALFRED J. THIEDE
Colonel, Corps of Engineers
District Engineer

FINAL
ENVIRONMENTAL IMPACT STATEMENT
DEEP DRAFT NAVIGATION IMPROVEMENTS IN HILO HARBOR
HILO AREA COMPREHENSIVE STUDY

The responsible State lead agency is the State of Hawaii, Department of Transportation, Harbors Division.

The responsible Federal lead agency is the US Army Corps of Engineers, and the cooperating Federal agency is the US Fish and Wildlife Service.

Abstract. Deep draft vessels operating in Hilo Harbor are hampered by insufficient water depth, surge (ship motion) during berthing, and lack of berthing and container space. The Corps has considered three plans to resolve problems and operational inefficiency in the harbor. Plan C, which involves deepening the harbor channel and basin, was found to resolve the problems with the least construction cost and the least modification to the existing harbor. Thus, the plan was designated the National Economic Development Plan, and was selected for implementation. Plan C does not involve the discharge of dredged or fill material under Section 404 of the Clean Water Act.

Bioassay and bioaccumulation tests and approval from the US Environmental Protection Agency are required before ocean dumping of the dredged material from Hilo Harbor can be implemented. If ocean disposal of dredged material is disapproved, other methods of dredged material disposal will have to be reevaluated.

SEND YOUR COMMENTS TO THE DISTRICT ENGINEER BY ________________.

If you would like further information on this statement, contact:

James E. Maragos, PhD
Chief, Environmental Resources Section
US Army Corps of Engineers
Building 230
Fort Shafter, HI 96858
Phone: (808) 438-2263

NOTE 1: The information, displays, etc., in the main report are incorporated by reference into the EIS.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont)

1. SUMMARY

1.1 MAJOR CONCLUSIONS AND FINDINGS. Three plans were evaluated in the Hilo Area Comprehensive Study, Deep Draft Navigation Improvements Study. These plans included Plan A--Improving the Inner Harbor, Plan B--Chamber of Commerce Plan, and Plan C--Harbor Deepening.

TABLE 1. PLAN FEATURES

Plan A	Deepen the harbor from -35 feet to -39/38 feet MLLW; ocean disposal of dredged material. Construct two new breakwaters.
Plan B	Realign existing breakwater. Enlarge channel and turning basin; use dredged material for fill. Create fill areas behind breakwater.
Plan C	Deepen the harbor from -35 feet to -39/38 feet MLLW; ocean disposal of dredged material.

Plan C is designated the National Economic Development Plan since it costs the least to implement, and resolves navigational problems in the harbor. Plan C is the Environmental Quality Plan since modification of the breakwater would enhance recolonization of Blonde Reef, would improve water quality while possibly reducing erosion along Bayfront Beach, and would increase the number of surfing sites in the bay.

No wetlands or flood plains are involved. Bioassay and bioaccumulation tests and approval from the US Environmental Protection Agency are required before ocean disposal can be implemented. The effects of the discharge of dredged and fill material were evaluated under Section 404(b)(1). Plan C does not involve the discharge of dredged or fill material. Plans A and B involve the discharge of dredged or fill material on Blonde Reef. The discharges are prohibited under Section 404(b)(1) evaluation since Plan C is an available, practicable alternative. The U.S. Fish and Wildlife Service prefers Plan C. Hilo breakwater is eligible for inclusion to the National Register of Historic Places. Plan C was determined to have no effect on the historic breakwater. However, Plans A and B do affect the visual elements of the breakwater. No prime agricultural lands are located within the project area. Because of its low cost, least environmental change, and non-structural design, Plan C is selected as the plan to be implemented.

1.2 AREAS OF CONTROVERSY. None.

1.3 UNRESOLVED ISSUES.

a. Ocean Dumping. The requirements for bioassay and bioaccumulation testing and US Environmental Protection Agency approval need to be completed prior to discharge of the dredged material at the ocean dump site. If the Environmental Protection Agency disapproves the ocean disposal of the dredged material, other methods of disposal will have to be evaluated.

1.4 RELATIONSHIP TO ENVIRONMENT REQUIREMENTS: (See Table 2).

1.5 ADOPTION OF AN EIS. The probable environmental impacts of ocean disposal of the dredged material at the disposal site are discussed in the US Army Corps of Engineers, "Final Environmental Impact Statement for Maintenance Dredging in the State of Hawaii," 1975, and the US Environmental Protection Agency, "Final Environmental Impact Statement for Hawaii Dredged Material Disposal Sites Designation," 1980, and are adopted for the purposes of this statement. The results of the bioassay and bioaccumulation tests will be documented in a supplement to this environmental impact statement.

TABLE 2. RELATIONSHIP OF THE PLANS TO ENVIRONMENT PROTECTION STATUTES AND OTHER ENVIRONMENTAL REQUIREMENTS

Federal Statutes	Plan A	Plan B	Plan C
Archaeological Resources Protection Act	Full	Full	Full
Clean Air Act	Full	Full	Full
Clean Water Act (See Section 6.2)	Partial	Noncompliance	N/A
Coastal Zone Management Act (See Section 6.2)	Partial	Partial	Full
Endangered Species Act (See Section 6.2)	Partial	Partial	Full
Estuaries Protection Act	N/A	N/A	N/A
Federal Water Project Recreation Act	Full	Full	Full
Fish and Wildlife Coordination Act	Full	Full	Full
Land and Water Conservation Act	N/A	N/A	N/A
Marine Protection, Research and Sanctuaries Act (See Section 6.2)	Partial	N/A	Partial
National Historic Preservation Act	Full	Full	Full
National Environmental Policy Act	Full	Full	Full
Rivers and Harbors Act	N/A	N/A	N/A
Watershed Protection and Flood Prevention Act	N/A	N/A	N/A
Wild and Scenic Rivers Act	N/A	N/A	N/A
Executive Orders, Memoranda			
Flood Plain Management	N/A	N/A	N/A
Protection of Wetlands	N/A	N/A	N/A

TABLE 2. RELATIONSHIP OF THE PLANS TO ENVIRONMENT PROTECTION STATUTES AND OTHER ENVIRONMENTAL REQUIREMENTS (CONT)

Executive Orders, Memoranda (Cont)	Plan A	Plan B	Plan C
Environmental Effects Abroad of Major Federal Actions	N/A	N/A	N/A
Analysis of Impacts on Prime and Unique Farmlands	N/A	N/A	N/A
State and Local Policies			
State NEPA (See Section 6.2)	Partial	Partial	Partial
State Coastal Zone Management Program (See Section 6.2)	Partial	Partial	Partial
County Special Management Area Permit (See Section 6.2)	Noncompliance	Noncompliance	Noncompliance
State Conservation District Use Application Permit (See Section 6.2)	Noncompliance	Noncompliance	Noncompliance
County General Plan	Full	Full	Full
State Land Use Plan	Full	Full	Full
Required Federal Entitlements (Permits)			
Non required			

NOTES:

a. Full (Full Compliance). Having met all requirements of the statute, Executive Order or other environmental requirements for the current stage of planning (either pre- or post-authorization).

b. Partial (Partial Compliance). Not having met some of the requirements that normally are met in the current stage of planning. Partial compliance entries should be explained in appropriate places in the report and/or EIS and referenced in the table.

c. Non-Compliance. Violation of a requirement of the Statute, Executive Order, or other environmental requirement. Non-compliance entries should be explained in appropriate places in the report and/or EIS and referenced in the table.

d. N/A (Not applicable). No requirements for the statute, Executive Order or other environmental requirement for the current stage of planning.

2. NEED FOR AND OBJECTIVES OF THE ACTION.

2.1 STUDY AUTHORITY. The study of Deep Draft Harbor Navigation Improvements in Hilo Harbor is conducted under Section 144 of the Water Resources Development Act of 1976. The Act authorizes a study of methods to develop, utilize and conserve water and land resources in the Hilo Bay area, including the consideration of the need for navigation facilities, for enhancement and conservation of water quality and, fish and wildlife, for environmental enhancement and for economic and human resources development. The recommendations shall be compatible with other local comprehensive development plans and plans of other interested Federal agencies.

2.2 PUBLIC CONCERNS.

a. The State of Hawaii, Department of Transportation, requested the assistance of the Honolulu District, US Army Corps of Engineers, to find methods of improving vessel operating efficiency in Hilo Harbor and of reducing damages due to ship motion. Some of the vessels presently using Hilo Harbor and of many of the projected future vessels cannot operate fully loaded in the existing harbor due to limiting water depths in the channel and turning basin. One of the vessels which regularly calls at Hilo has trouble turning in the basin because of the basin's limiting size. The turning basin is further restricted by a mooring buoy located in the middle of the turning basin. However, the buoy is used to safely berth vessels when ship motion alongside the dock becomes severe. The turning basin is also restricted when berthing space is overcrowded and vessels have to moor in the turning basin. The restriction in the turning basin delays ship or barge turnaround time, increases the chances for accidents, and requires the use of extra tugs. Ship motion is a major concern to vessel operators, port officials, and local businesses since the problem prevents vessels from unloading in Hilo, and causes damages to both vessels and wharves.

b. Local residences and agencies have expressed a need to improve water quality in Hilo Bay. The turbid waters and accumulated vegetative trash on the bayfront beach reduce recreational aesthetics and discourages water contact recreation. Fishermen complain of low recreational catches, and commercial fishing in the bay has declined. The bay is presently recovering from 75 years of sewage and industrial discharges, but contaminants are still present in the harbor sediments. Hilo Harbor breakwater reduces water exchange and circulation in the bay, induces heavy sedimentation which eliminates hard bottom habitat, and creates a two-layered water body by trapping freshwater discharged into the bay by springs and rivers. Local residents do not wish to see tsunami hazards aggravated and believe that the breakwater provided some protection from past tsunamis.

2.3 PLANNING OBJECTIVES.

a. Provide adequate improvements in the harbor and facilities to accommodate deeper draft and longer vessels of the existing and future fleets.

b. Improve water quality, fish habitat, and water-contact recreation in Hilo Bay through modifications of the breakwater.

c. Prevent any aggravation of tsunami hazards in Hilo Bay.

3. ALTERNATIVES, INCLUDING THE PROPOSED ACTION.

3.1 PLANS ELIMINATED FROM FURTHER STUDY.

a. Widening the turning basin. Plans to widen the basin by dredging were eliminated because the plans considered in detail provided solutions to problems in Hilo Bay without dredging a wider turning basin.

b. Scheduling vessel arrivals. This alternative is a management action implemented by the local government to reduce delays related to surge and to efficiently utilize existing berthing and container storage space. The alternative was not considered in detail because scheduling control has been effectively implemented by local port authorities.

c. Removing the mooring buoy. The mooring buoy which is presently located in the turning basin is used to prevent ship and wharf damage during periods of strong surge, which slams ships against the wharf. While removing the buoy can open up the turning basin to ship traffic, the action does not eliminate navigation problems associated with limiting water depths and the lack of mooring space which forces ships to moor in the turning basin. The construction of a submersible mooring buoy, which can be raised and lowered when needed, would improve the situation. The local government could improve the wharf fender and mooring system in an effort to reduce surge damages. Such improvements could involve replacement of the wooden fender system with cylindrical rubber fenders and the installation and use of pretensioning winches to handle mooring lines to dampen ship motion next to the wharf. These actions could be implemented by the local government in conjunction with Federal efforts to deepen the turning basin.

d. Modifying the breakwater. The Draft Navigation Improvement Report and DEIS contained an alternative involving the deauthorization of the outer 7,500 feet of the existing breakwater and construction of a new 2,000-foot breakwater to protect the harbor. This alternative has been eliminated from this report and is being submitted as a separate study.

3.2 WITHOUT CONDITION (NO ACTION). Radical changes in cargo composition and tonnage traffic are not anticipated, but tonnage is expected to increase in relation to demands resulting from the continued growth of Hawaii County's population. The limitations in harbor depth (29 feet Controlling depth) and the lack of berthing and cargo storage space will continue the harbor inefficiency. Barge traffic volume is expected to remain unchanged, but a deeper draft integrated tug and barge (36 feet draft) is expected to be put into service. Two petroleum tankers with 36 feet design draft presently must underload to operate in Hilo Harbor and will continue to do so in the near future. Existing and future bulk carrier vessels have design drafts greater than 30 feet and will continue operating in Hilo Harbor. The State plans to expand the berthing area in Hilo Harbor along Baker's Beach, which will provide more container storage space, and to align the berthing area, to minimize present surge problems. No change in existing water quality parameters or water-contact recreation problems is anticipated.

3.3 PLANS CONSIDERED IN DETAIL. Three plans were considered in detail for improvements to Hilo Harbor. Plan C, Harbor Deepening is designated the National Economic Development Plan because it has the least construction cost for implementation in comparison to the other plans. Plan C also involves the least amount of energy to implement due to its low construction cost and lack of major structural elements. Only Plan B requires an increase in potable water demand because it provides for more extensive landside facilities in comparison to other plans.

a. Inner Harbor Improvements (Plan A). This plan consists of deepening the existing entrance channel and turning basin from -35 feet MLLW to -39 and -38 feet MLLW, respectively and constructing two new breakwaters, one 900 feet in length and the other 2100 feet in length (see Figure 4). The plan has a benefit-cost ratio of 0.4 and has a total investment cost of $23.5 million with the Federal share being $23.1 million and the State share being $0.4 million. Baker's Beach is left open for harbor expansion as planned by the State. The plan effectively reduces surge problems and improves operating depths and turning within the harbor. Water circulation within the inner harbor is further reduced, but areas outside the inner harbor are unaffected. Water turbidity will temporarily increase due to dredging. The maintenance dredging frequency may be decreased from once every 10 years to once every 15 years, reducing the frequency of benthic community disturbance and associated ocean disposal impacts. The two breakwaters add new visual elements in the bay which is already dominated by the visual presence of the existing breakwater.

The breakwaters will provide rocky interstitial habitat while eliminating silt covered coralline habitat. Approximately 249,000 cubic yards of contaminated, silty-clay, dredged material will be disposed of in the ocean, depending upon the outcome of bioassay and bioaccumulation tests and approval of the action by the US Environmental Protection Agency. If the Environmental Protection Agency does not approve of the action, other alternatives for disposal of the dredged material will have to be reconsidered including land disposal, containerization or encryptment on land or in the ocean, and varying the rate of dilution and discharge into the ocean. Land disposal costs are less than ocean disposal costs within 4.5 miles of the harbor, but no land disposal sites are available within 6 miles of the harbor and land purchases will increase disposal costs. Suitability for uncontained land disposal will depend upon the results of leachate testing and U.S. Environmental Protection Agency leachate standards for land disposal of hazardous materials. Potential tsunami damage and losses will be increased by locating 2 new breakwaters within the tsunami hazard area.

b. Chamber of Commerce Plan (Plan B). This plan consists of a major realignment of the breakwater, expansion of the turning basin by dredging, and creating fill areas along the harbor side of the breakwater for container storage space, a small boat harbor, and a recreational park using the dredged material (see Figure 5). This plan has a cost-benefit ratio of 0.1 and a total first cost of $138.7 million with the Federal share being $61.4 million and the State share being $77.3 million. This plan creates the greatest environmental change in the bay in comparison with the other plans. If implemented, approximately 200 acres of reef area will be dredged and 85 acres filled. The discharge of dredged or fill material will have to conform with the US Environmental Protection Agency Section 404(b)(1), Clean Water Act, guidelines and possibly undergo bioassay and bioaccumulation analysis due to the presence of contaminants in the harbor sediments. The dredging and discharge of dredged material will temporarily increase water turbidity within the harbor, and eliminate 285 acres of fishery habitat on Blonde Reef. The landfill does not effect water-contact recreation activities along the Bayfront area. Potential tsunami damages and losses will be increased by locating damageable properties in the tsunami hazard area, particularly along the breakwater. The plan also realigns a portion of the historic Hilo breakwater and increases the land area adjoining the breakwater modifying the visual elements in the bay.

c. Harbor Deepening (Plan C - the Selected Plan). This plan consists of deepening the existing harbor as described and discussed in Plan A. (See Figure 7.) This plan has a cost-benefit ratio of 2.0 and a total first cost of $3.8 million with the Federal share being $3.5 million and the State share being $0.3 million. This plan causes the least amount of environmental change in comparison with the other plans. A temporary increase in water turbidity is anticipated with dredging and ocean disposal. The Environmental Protection Agency requirements, as discussed in Plan A, will have to be fulfilled. The maintenance dredging frequency for Hilo Harbor may decrease from once every 10 years to once every 15 years with the deeper water depths. This plan replaces the existing mooring buoy with a submersible one.

3.4 COMPARISON OF ALTERNATIVE IMPACTS. (See Table 3.)

TABLE 3. COMPARISON OF ALTERNATIVE IMPACTS

Resource	Base Condition	Plan A	Plan B	Plan C
Recreation Beach Parks	Mooheau Park eroding	No effect	No effect on existing parks.	No effect
	Bayfront Park eroding canoeing	"	Adds new park.	"
	Wailoa River Park	"	No effect	"
	Liliuokalani Gardens and adjacent areas	"	"	"
	Coconut Island	"	"	"
	Banyan Drive shoreline	"	"	"
	Reed's Bay swimming	"	"	"
	Baker's Beach	"	"	"
	Radio Bay	"	"	"
	Radio Bay Park	"	"	"
	Hilo Breakwater fishing	Adds 2 new breakwaters	Improved access, reduced hazards, adds 3 new breakwaters.	No effect
Surfing	Coconut Island area (1)	No effect	No effect	No effect
	Wailuku River Mouth (3)	"	"	"
	Tip of Hilo Breakwater (1)	"	"	"
Fishing	Hilo Breakwater	Adds 2 new breakwaters	Improved access, adds 3 new breakwaters, eliminates 200 acres of reef.	No effect
	Shoreline areas	No effect	No effect	No effect

TABLE 3. COMPARISON OF ALTERNATIVE IMPACTS (CONT)

Resource	Base Condition	Plan A	Plan B	Plan C
Boating	Wailoa River shoaling	No effect	No effect	No effect
	Radio Bay	"	"	"
	Reed's Bay	"	"	"
			Add new boat harbor	
Natural Hazards				
Volcanic	High risk	No effect	No effect	No effect
Tsunami	Very high risk	Increase potential damages.	Increased potential damages.	No effect
Endangered Species				
Humpback Whale (endangered)	No critical habitat in harbor, seasonal migration offshore.	No jeopardy	No jeopardy	No jeopardy
Hawksbill Turtle (endangered)	No critical habitat seen in harbor possibly foraging.	No jeopardy	No jeopardy	No jeopardy
Green Sea Turtle (threatened)	No critical habitat seen in harbor possibly foraging.	No jeopardy	No jeopardy	No jeopardy
Hawaiian Coot (endangered)	Two nests in Waiakea Pond	No effect	No effect	No effect
Migratory Waterbirds				
Ducks	Winter population in Waiakea Pond.	No effect	No effect	No effect

TABLE 3. COMPARISON OF ALTERNATIVE IMPACTS (CONT)

Resource	Base Condition	Plan A	Plan B	Plan C
Estuaries				
Waiakea Pond		No effect	No effect	No effect
Wailoa River		No effect	No effect	No effect
Wailuku River		No effect	No effect	No effect
Terrestrial Area	None	None created	85 acres created	None created
Marine Resources				
Blonde Reef	16% coral cover, 220 acres.	6 acres covered 4 acres rocky intertidal habitat created.	200 acres dredged, 85 acres covered. 7 acres rocky intertidal habitat created.	No effect
Coconut Island Reef	10% coral cover 40 acres.	No effect	No effect	No effect
Fishery Resources	Recreational value high. Number of fish species high.	No effect	Possible decrease in resource abundance.	No effect
Water Quality	Data incomplete to compare with State Water Quality Standards.			
	High salinity gradient.	Increased gradient in inner harbor.	No effect	No effect

TABLE 3. COMPARISON OF ALTERNATIVE IMPACTS (CONT)

Resource	Base Condition	Plan A	Plan B	Plan C
Water Quality (Contd)	High turbidity, high nutrient concentration.	Temporary turbidity stress; 190 days.	Temporary turbidity stress; 2 years.	Temporary turbidity stress; 190 days.
	High sedimentation.	No effect or sedimentarate, make reduce sedimentation rate in inner harbor.	No effect or sedimentation rate.	No effect
	Pollution discharges terminated.	No pollution discharges.	No pollution discharges. Increased stormwater runoff from commercial wharf areas.	No pollution discharges.
Sediment Quality	Sediments contaminated with Arsenic, PCB and Pesticides.	No change	No change	No change
Ocean Dumping	Proposed site available.	551,400 cy	No dumping required.	551,400 cy
Historic Properties Hilo Breakwater	Hilo Breakwater eligible for inclusion to National Register of Historic Places.	No effect, adds two new breakwaters.	Effect not adverse. Realignment, add 3 new breakwaters, and 85-acre landfill.	No effect
Discharge of Fill or Dredged Material	Not applicable.	200,700 cy of stone for the breakwaters.	5,242,500 cy of dredged coralline material 603,300 cy of rock). for the breakwaters and revetments.	None required.

4. AFFECTED ENVIRONMENT.

4.1 ENVIRONMENTAL CONDITIONS.

a. Hilo is the capital and business center of the County of Hawaii. The 1980 population of Hilo was 42,320 (State of Hawaii, 1980), and continues to grow at a slow rate in comparison to the Kona side (western side) of the island. Hilo is considered a mildly depressed area with disproportionately higher unemployment than the State and has one of the lowest visitor counts in a State in which tourism is a major industry. Hilo's principal industry is sugar production, which is stable but not growing. The principal employers in Hilo are government, services and trades. The city of Hilo is situated along the shoreline of Hilo Bay and is a fully developed urban area. A University of Hawaii extension campus is located in the city together with the main county hospital, modern shopping centers and a variety of other commercial establishments. Hilo Harbor is the principal port-of-call and handles the most of cargo, agricultural and petroleum shipments in the County.

b. Hilo Bay shoreline is developed park open space as a result of local land use zoning in the tsunami hazard area. Residences are located along Baker's Beach and on Waiakea Peninsula along Banyan Drive. The developed nature of the shoreline and the high urbanized nature of the area precludes significant vegetation and wildlife habitats, except in Waiakea Pond and Wailuku River. The breakwater, Wailoa and Wailuku Rivers, and groundwater seepage into Hilo Bay are the principal factors influencing water quality in the bay. The breakwater traps freshwater discharged into the bay and reduces water circulation and exchange creating a significant salinity gradient in the bay. Sediment, cane and vegetation trash carried into the harbor by the tributaries discourage water contact recreation in the bay. Boating, recreational fishing, canoeing, and surfing are the significant water contact recreational activities in the bay. Commercial fishing in the bay has declined although the principal commercial fishing facility in the region is located at Suisan Harbor in the mouth of the Wailoa River.

4.2 SIGNIFICANT RESOURCES.

a. Recreation. Recreation occurs all along the bay shoreline. Mooheau and Bayfront beach parks extend along the bay shoreline from the Wailuku River to the Wailoa River. There is both boat berthing and open space recreation in Wailoa River Park. Liliuokalani Gardens and Coconut Islands provide open space along the Waiakea Peninsula. Reed's Bay and Baker's Beach are swimming areas relatively free of trash from the Wailuku and Wailoa Rivers. Radio Bay is used for berthing of recreational craft and the Radio Bay Park provides additional open space within the harbor area. Hilo Breakwater is a popular fishing site, despite signs warning fishermen of the hazardous conditions on the breakwater. The breakwater is frequently overtopped during high surf conditions, and waves can sweep fishermen from the breakwater. Recreational fishing is the most significant recreational activity in the bay. Fishermen use every location in the bay as a fishing site, including the harbor facilities. Boating and canoeing are also important recreational activities together with wading. Swimming is not a major recreational activity, possibly due to the highly turbid waters, and the trash in the water and on the shoreline. Five surf sites in the bay were identified by Kelly, 1981 (See Appendix B for details).

b. Natural Hazards.

(1) Volcanic Hazards. Hilo is located in a high risk volcanic area exposed to lava flow threats, earthquakes and subsidence (See Appendix B). The risk generally decreases with distance from the northeast rift zone of Mauna Loa volcano. During the past 15 years the island of Hawaii has experienced 11 earthquakes with Richter magnitude ratings of 6 or more. The most recent in 1975 resulted in an estimated $4 million dollars of damage island wide. Most lava flows from Mauna Loa have stopped short of the Hilo suburbs. Public fears of volcanic damages and losses are still significant. At the present time, the Corps of Engineers is seeking Congressional authorization at the request of the State of Hawaii to react to threatening lava flows under emergency conditions.

(2) Riverine and Tsunami Flood Hazards. Hilo is subject to riverine flooding principally due to high intensity rainfall and surface runoff in undefined drainage ways. The flood prone areas are located within the Alenaio Stream floodplain, which is a tributary to the Wailoa River. Hilo is also subject to tsunami flood hazards. The tsunamis of 1946 and 1960 were particularly destructive resulting in the loss of 234 lives and about $52 million in property damage. After the 1960 tsunami, vulnerable waterfront areas were rezoned to open space, such as the Bayfront and Wailoa River Parks, and structural design regulations were imposed in order to reduce tsunami damages. The harbor area is located within the tsunami flood hazard area.

c. Endangered Species. The endangered humpback whale seasonally migrates through waters outside of Hilo Harbor. The whales begin to appear in November and leave the islands by the end of June. The greatest number of whales in the islands appear during February and March. The National Marine Fisheries Service indicates that no whales have been sighted inside Hilo Harbor. Data indicate that the whales concentrate at Upolu Point in northern Hawaii, and suggest that the Hilo Harbor area is not a calving, nursing and breeding area in the Hawaiian Islands. The endangered hawksbill turtle and the threatened green sea turtles have been observed in Hilo Harbor, but no nesting grounds exist in the harbor and no seasonal aggregations in the harbor have been reported. The turtles are also reported by the US National Marine Fisheries to forage along the entire coastline from Hilo to Kalapana.

d. Endangered and Migratory Waterbirds. The endangered Hawaiian coot was reported nesting in Mouholi Pond within Waiakea Pond. The pond has not been declared a wildlife refuge or critical habitat for the coot by the US Fish and Wildlife Service. During the winter season, migratory ducks are frequently seen in Waiakea Pond.

e. Estuaries. Reed's Bay, Waiakea Pond, Wailoa River and Wailuku River are estuaries within the Hilo Bay and Harbor area. Approximately 1000 mgd of freshwater is discharged into the harbor from the tributaries and springs. The estuaries are important recreational fishing areas within the bay and are planned for open space. Reed's Bay, Wailoa River and Waiakea Pond are planned by the local government for park use, and Wailuku River is planned as a natural wilderness area.

f. Marine Resources. The two important marine areas within the bay are the areas with the greatest coral cover, Blonde Reef (16% coral cover) and Coconut Island (10% coral cover). Both the live and dead coral mass on Blonde Reef and at Coconut Island provide habitat for a variety of reef fish important to recreational fishing in the bay. Commercial fishing in the bay has declined, but the sale of the catch occurs at Suisan Harbor and fish market at the mouth of the Wailoa River. Fishermen suggest that fish stocks are declining due to over-exploitation, sedimentation and chemical pollution. However, exact factors affecting fish abundance have not been determined, although, high water turbidity reduces spear fishing success and sedimentation can bury fish shelter and food resources reducing the amount of nearshore fish habitat. Nehu (tuna fishing bait fish) resources have declined and are insufficient to support a fishing fleet. Principal nehu catch areas are located within the commercial port.

g. Water Quality.

(1) The data are insufficient to compare existing conditions with new State of Hawaii Water Quality Standards which were revised in September 1979. Based on previous standards, water quality in Hilo Bay was poor due to high nutrient concentrations, high water turbidity, high suspended solids concentration and high chlorophyll-a concentration. However, water quality is significantly improved from the past when sugar mills, the Canec Plant and the City of Hilo discharged their wastewaters directly into the bay.

(2) In general, water inside and outside the breakwater is vertically stratified due to the discharge of ground and riverine water into the ocean. The salinity gradient inside the harbor is greater than that outside due to the reduced mixing behind the breakwater. The depth of the freshwater layer in the bay reaches 20 feet indicating that mixing is occurring between surface and bottom layers, but not sufficient to reduce the salinity gradient. The depth of freshwater on Blonde Reef reaches 10 feet inside the breakwater. The primary water column mixing forces are wind and occassional ship traffic. Nutrient concentrations and suspended solids and turbidity vary with the volume of surface runoff and groundwater discharge entering. Fecal strep bacteria tend to survive longer in the bay due to the freshwater layer in the bay than other areas in the State. Chlorophyll-a concentration vary with water turbidity increasing during periods of low riverine flow and decreasing during periods of high flow. Water temperature in the surface layer is warmer than the bottom layer due to solar heating, but is colder near the source of groundwater discharge. During periods of low freshwater discharge, solar heating can warm the bottom layer because the depth of the freshwater layer is reduced.

h. Sedimentation and Sediment Quality. The sediment in the harbor entrance channel and turning basin consists of silty-clays. The low wave energy environment behind the breakwater allows much of the water-borne sediment to settle out in the harbor and on Blonde Reef where the sediment smothering and destroying the reef ecosystem. The rate of sedimentation may be slow based upon the frequency of maintenance dredging in Hilo Harbor -- once every ten years. In 1977, about 54,000 cubic yards of material was removed from the harbor during the maintenance cycle and the material was disposed of by ocean dumping at the EPA approved Hilo ocean disposal site. However, about 35,000 tons of silt per year are deposited in the bay from the Wailuku River, the quantity may be less than in the past, because a 1881 lava flow, covered up erodible soils within the Wailuku River drainage basin and the discharge of 20,000 tons of sediment a year from the Wainaku Sugar Mill was terminated in 1976. Based upon sediment analysis by the State Department of Health, Hilo Bay sediments are contaminated with arsenic, PCB and chlordane. Arsenic trioxide was discharged into Waiakea Pond by the Canec Plant. The PCB's probably orginated from the Shipman Power Plant near the Wailoa River. Chlordane probably occurs due to agricultural activities and use as a termicide in home construction in Hilo.

TABLE 4

Contaminant Concentration in Hilo Harbor Sediments.

Total Arsenic concentration: Range from 33-104 ppm

PCB concentration: a mean value of 200 ppb

Chlordane concentration: a mean value of 2-84 ppb

Source: State of Hawaii 1978

Tests of crab and fish tissue indicate that arsenic and PCB are not bioconcentrating in the tissue. Fish viscera contained chlordane residue in concentrations 3-4 times higher than the flesh, where concentrations ranged from 80-160 ppb.

i. Ocean Disposal Site for Dredged Material. In 1981, the US Environmental Protection Agency designated a permanent ocean disposal site for dredged material of Hilo Harbor. The site is located 8 miles northeast of Hilo Harbor in ocean depths ranging from 330 to 340 meters. The surface currents in the area ranged in velocity from 15 to 36 cm/sec in a predominantly northwesterly direction. The bottom sediment was silty clay, and the site is also located outside of the major commercial fishing grounds. The dump site is not a site of upwelling. In 1977, about 54,000 cubic yards of dredged material from Hilo Harbor were discharged at the dump site. In 1962, approximately 85,000 cubic yards of dredged material was removed from Hilo Harbor and disposed of in the ocean offshore from Hilo.

TABLE 5

EPA Dredged Material Disposal Site for Hilo Harbor

Location: Center Point Latitude 49° 48" 30" N
Longitude 154° 50' 30" W

Size: Circular with radius of approximately 920 meters

Primary Use: Dredged Material

Period of Use: Continuing use

Restriction: Disposal shall be limited to dredged material

Source: Federal Register, (46)115: June 16, 1981 (31412).

j. Air Quality. Air quality in Hilo is good, lacking major industrial emissions. The sulfur dioxide concentration in 1980 was less than 5 micograms per cubic meter. Volcanic gases, agricultural fires, sugar mills, both aircraft and automotive engines and the power plant are the only major sources of air pollution in the Hilo area.

k. Noise. Hilo is a quiet urban area with the exception of aircraft landing and taking off from Hilo Airport, the aircraft landing pattern takes aircraft over the bayfront area.

l. Historic Resources. The Hilo Breakwater was determined to be eligible for inclusion to the National Register of Historic Places by the Keeper of the Register in 1980. The Keeper of the Register indicated that the breakwater was significant to Hawaii Island commerce and transportation for the vital role that it played in the development of the port of Hilo, the historic main port of entry for the island of Hawaii, and that the breakwater has retained its essential physical integrity despite alterations to its original design, function and visual appearance. The State Historic Preservation Officer had indicated that the breakwater was associated with events that facilitated railroad and port expansion in Hilo, that reestablished Hilo as the hub of transportation on the island of Hawaii and that contributed to the growth of Hilo. The 2-mile long breakwater is also the longest breakwater in the State and continues to be a visible entity in the bay. For 50 years the breakwater has been a major visual element in Hilo Bay despite damage by tsunamis.

5. ENVIRONMENTAL EFFECTS.

5.1 Social. The improvements will not alter Hilo's population growth or influence its existing economic trend. No people, farms or businesses will be displaced. The harbor remains in industrial and commercial use, and management will remain with the State of Hawaii.

5.2 Recreation. None of the plans will have a direct impact on existing park areas in Hilo Bay. The construction of two new breakwaters in Plan A will attract fishermen and increase the amount of fishing sites in Hilo Bay, despite warnings that the fishing locations on the breakwaters are hazardous. Plan B provides the largest increase of recreational fishing area by creating 85 acres of land area from Blonde Reef for use as park, small boat harbor and container storage. Plan C makes no contribution to recreation in Hilo Bay and will not degrade existing recreation resources.

5.3 Natural Hazards.

a. Volcanic Hazards. None of the plans increase volcanic hazard risks.

b. Tsunami and Riverine Flood Hazards. None of the plans affect riverine flooding along the Alenaio Stream floodplain. Plan B increases the amount of damageable property, i.e., container storage, small boat harbor, located within the tsunami hazard zones. Plan A located two new breakwaters in the tsunami hazard area also increasing potential tsunami damages.

5.4 Endangered Species.

a. Endangered humpback whale. None of the plans will affect the migratory route of the humpback whale, or any critical whale calving, nursing or breeding areas in Hawaii. Ocean disposal of dredged material under Plans A and C would occur in offshore waters used by the whales. If the dumping was conducted during the migratory season, the dumping would not hinder whale movement through the area. The operation of the conveyance vessel would create underwater sounds which the whales may find unpleasant, but should not affect their migration. In Glacier Bay, Alaska, the operation of tour boats averaging about 100 tons displacement appeared to interfere with whale feeding and possibly their use of the area. However, during their migration through Hawaiian waters, the whales are not known to feed and are not confined in an embayment.

b. Endangered hawksbill turtle and threatened green sea turtle. Plan C involves the least modification to the existing harbor and does not alter available foraging in Hilo Harbor. Plan B involves the greatest change to the existing harbor and eliminates 285 acres of Blonde Reef, which may be used for foraging by the turtles. None of the plans would affect turtle nesting areas or areas of turtle aggregations in Hawaii. The plans would not eliminate foraging area along the coast outside of Hilo Harbor.

c. Endangered Hawaiian Coot. None of the plans involve modification of Waiakea Pond where the endangered Hawaiian Coot was reported nesting.

5.5 Migratory Waterbirds. None of the plans involve modification of Waiakea Pond where migratory ducks have been observed.

5.6 Estuaries. None of the plans involve work in the Wailuku River, Wailoa River, Reed's Bay estuaries.

5.7 Marine Resources.

a. Dredging in Hilo Bay will involve removing material from Blonde Reef and the silty areas in the commercial port. The activity will eliminate resident benthic infauna within the dredged areas and will temporarily increase siltation and turbidity stress in adjacent areas. Recolonization of dredged and stressed areas is anticipated, but species diversity on Blonde Reef will be lowered by decreasing the available hard substrate and creating more silty habitat. Recolonization of the silty mud environment will occur more quickly and by different species compared to damaged coral areas because of the homogenity of the habitat and the relatively high mobility and tolerance of the fauna to sediment compared to reef organisms attached on the solid substrate. However, the benthic faunal assemblage will be less diverse than the reef.

b. During dredging, an artificial feeding situation will develop as predatory fish will exploit food resources displaced, exposed, or stirred up by the dredging activities. This fish concentrating effect will attract fishermen to the area. The loss of a portion of Blonde Reef is not expected to eliminate the presence of any fish resource in the bay, but it may influence the abundance of some species by reducing available reef habitat.

c. Plans A and C involve removing silt from 80 acres of muddy, silt bottom habitat within the existing harbor entrance channel and turning basin. The loss of any benthic infaunal organisms would be typical of the impact associated with present periodic maintenance dredging activities. The dredging activities would temporarily increase water turbidity adding to the sedimentation and turbidity stress already experienced in the harbor and on Blonde Reef. The extent of turbidity and sedimentation stress cannot be accurately predicted in light of the heavy siltation and turbidity present in the harbor due to the Wailuku River. However, the extent of stress maybe grossly estimated based upon the number of days it takes to complete the dredging action. Plan B involves dredging and filling 200 acres of Blonde Reef reducing the available coral and fishery habitat in Hilo Bay and temporarily increasing sedimentation stress. The Plan will create 120 acres of silt habitat which would have a lower diversity of organisms and a lower abundance of recreationally important fish.

5.8 Water Quality.

a. All plans involve dredging and a temporary increase in water turbidity as a result of dredging. The impact is a cumulative impact which adds to the stress already created by the influx of sediment from the tributaries entering Hilo Bay. Usually the color of the water returns to normal within a day after each dredging operation, but transmissiometer and visual underwater observations indicate that fine sediments remain in suspension longer obscuring underwater visibility. The duration of dredging is used as a gross indicator of the extent of turbidity change anticipated. None of the plans affect the amount of sediment carried into the harbors, but the changes to the current patterns in the bay will alter the sedimentation patterns.

b. Hilo Harbor has a silty-clay bottom and deepening the channel and turning basin from -35 feet MLLW to -39 feet and -38 feet MLLW, respectively could probably be performed using a hopper dredge (ship type dredge with suction booms and dredge material storage bins (hoppers)) during a normal maintenance dredging cycle. However, hydraulic suctions dredges and mechanical clamshell dredges could also be used. The hydraulic dredge could pump fluid mud from the harbor bottom into a barge which would be towed to the dump site. Overflow water usually contains fine silt and creates a highly turbid plume. Clamshells or draglines without containment buckets also cause turbid plumes, but the cohesive clays stay within the bucket. While material falling from the bucket and water draining from the bucket contribute to water turbidity, a fluid mud condition, where the sediment is entrained in a large volume of water, is not created. In dredging the harbor under Plan B, where the dredged material is used for construction material, a hydraulic cutter head dredge would probably be used and the material pumped to the contained, fill site. Turbidity plumes would also be expected, but the containment area confines the discharged dredged material slurry, allowing time for the material to settle out from the water. Water returning to the harbor could be less turbid than the harbor water, if sufficient settling time is allowed within the containment area.

c. Sedimentation and turbidity stress related to dredging is dependent upon the characteristics of the material being dredged, the type of dredge used, and the direction and strength of water currents in the dredge area. The material dredged from Hilo Harbor is expected to consist of silty-clays from the existing harbor channel and basin, and coralline rubble and rock aggregate from Blonde Reef. Blasting may be required. A suction dredge with barge and a mechanical dredge, clam shell or dragline, have the potential of increasing suspended sediment load, turbidity conditions, and siltation stress because water turbulence and water draining from the bucket and barge can wash dredged material into the bay. Hydraulic suction dredges combined with land disposal of dredged spoils create the least amount of water turbidity since material and water are drawn from the bottom and pumped to a retention pond where sediment is allowed to settle out of the water. Leaks from the pipelines and physical disturbance of the bottom are primarily responsible for turbid plumes associated with hydraulic dredging. The material previously dredged from Hilo Harbor during the 1977 maintenance dredging consisted entirely of silty-clay; 50% of the material had a grain size smaller then 0.010 millimeters. While most of the material dredged may be plastic and cohesive, some loose fine material can be washed into the water where the material can remain in suspension for a considerable length of time. For example, a particle with a grain size of 0.10 can take about 33 minutes to settle 1-foot in the absence of strong currents. Dredging on hard coral and rock can create fine silt particles, but most of the material will probably be coarse to medium size material with large grain sizes that can settle out quickly. For example, particles with grain size in the range of 5 to 1 mm can settle 1-foot in 0.3 to 3 seconds. Much of the fine material suspended by dredging on hard substrates is usually material which has settled out from the water column. Drogue studies (Reference M. & E. Pacific, 1980) indicate that water currents will carry turbid water from the commercial harbor out to the harbor mouth. However, the closer dredging is located to Blonde Reef, the greater the possibility that suspended silt will be carried over the reef.

d. Rough calculations indicate that current velocities in the commercial harbor range from 0.03 to 0.19 knots and can convey non-cohesive fine silt particle (size 0.10 mm) a long distance (9,200 feet based on a particle settling velocity of 0.0005 feet/second, current speed of 0.3 knots, and water depth of 16 feet) from the dredge site. Coarse material (size 5mm) can settle out within 14 feet of the dredge site (based on particle settling velocity of 0.33 feet/second, water depth of 16 feet and current speed of 0.3 knots). Medium grained material will probably have a more detrimental effect on reef life than fine or coarse material. The medium material is expected to have a settling rate which may exceed tolerance of some benthic species. The material will settle out within moderate distances from the dredge, where it can bury or smother benthic organisms, and cannot easily wash from the surface under reduced wave conditions experienced in Hilo Bay. While turbidity can induce stress to photosynthetic organisms, the effect is temporary as water clarity will return to ambient levels after termination of dredging. The period of stress may be long, depending upon the length of time required to complete the dredging, and can be aggravated by rainfall induced turbidity. Periodic rainstorms impart similar sediment stresses in Hilo Bay because large amounts of sediments can be discharged from rivers and streams entering the bay.

e. The breakwaters in Plan A further restrict mixing within the inner harbor and will possibly increase the salinity gradient within the harbor due in part to the groundwater dishcarge in the inner harbor. The groundwater discharge will probably create a net surface outflow from the harbor and may tend to keep sediment laden water from the tributaries out of the harbor basin possibly reducing the rate of sedimentation in the harbor turning basin.

f. Plan B reduces the water surface area in the harbor by 85 acres and deepens 200 acres of the harbor. The shallow areas in the harbor have a good rate of water exchange due to tide and movement of the top layer of water in comparison to the deep areas in the harbor where tidal movement is the principal factor affecting water movement and exchange. The increased land surface area along the breakwater increases surface runoff from the commercial and industrial area which will contribute roadway pollutants into the bay.

g. Plan C does not affect water quality in the bay because it involves the least modification to the existing bay environment. The anticipated increase in ship traffic in the bay may also help to improve water column mixing, as the ship propellors create forces which mix the two water layers in the bay.

h. Sediment Quality. None of the plans will improve or further degrade sediment quality. The removal of 249,000cubic yards of contaminated sediment in Plans A and C may temporarily improve conditions in the bottom for infaunal organisms, but the continued movement of contaminants from inland and upland sources into the bay and the movement of contaminated sediment in the bay into uncontaminated areas maintains existing conditions in the bay sediment quality.

5.9 Ocean Dumping.

a. The probable impacts of ocean dumping are discussed in the Corps of Engineers, "Final Environmental Impact Statement Harbor Maintenance Dredging in the State of Hawaii," 1975, and the US Enviromental Protection Agency, "Final Environmental Impact Statement for Dredged Material Disposal Site Designation", 1980. In summary, the dump site has a silty-clay substrate and is dominated by a polychaete infauna. The level of biological activity is lower than in shallower coastal waters. The site is not a significant commercial fishing ground. The water depth and coastal currents provide significant dilution and dispersion of the dredged material. Agitation of the dredged material in the water column may create a temporary nutrient increase and a temporary depression in dissolved oxygen concentrations. Short-term biostimulation may occur, together with mounding and faunal shifts on the bottom. Suspended sediment load and water turbidity will temporarily increase. Some plankton may be entrapped in the sediment falling through the water column. The material deposited on the ocean bottom will smother some organisms, but repopulation is anticipated. Toxic effects and pollutant accumulation are possible, and bioassay and bioaccumulation tests performed prior to disposal will be used to assess the effects of the material on test animals representing the population of both the dump and dredging sites. In accordance with US Environmental Protection Agency regulations, bioassay and bioaccumulation tests on the dredged material will be performed and the results submitted to EPA for their review and approval of the ocean dumping activity. The tests are designed to predict toxic effects of the dredged material on organisms representative of the dump site and any bioaccumulation which might occur. However, the use of representative organisms does not accurately predict conditions and consequences which may occur in the actual deep ocean environment where organisms and environmental conditions are poorly studied and not well documented or researched.

b. State Department of Health analysis of sediment samples from Hilo Bay suggest that dredged material from the silty environment contain high concentrations of arsenic, PCB and chlordane. The results of bioassay and bioaccumulation analysis may find the material unsuitable for ocean dnumping in accordance with EPA criteria. However, the presence of the pollutants may also make it unsuitable for land disposal. If so, the material may have to be either mixed with non-toxic material to dilute its toxicity, packaged prior to disposal, incinerated, biologically or chemically treated, or discharged into the ocean at a low rate to allow adequate dilution. In the aquatic environment, the pollutants, especially heavy metals, are in a stable physiochemical environment not subject to wide variations in pH or reduction-oxidation (redox) potential. Thus, the pollutants tend to be bound to the sediments and not readily available for biological uptake. When sediments are stirred up either by wave energy or dredging, the concentrations of pollutants initially increases, but rapidly decrease as the materials are oxidized.

5.10 Upland Disposal. In upland disposal sites, the dredged material undergoes a wide variation in pH and redox potential, and pollutants are readily released from the material. The presence of the pollutants can toxify the soil, preventing the growth of plants or limit the availability of other nutrients needed for plant growth. The pollutants can also be leached from the soil into the groundwater where they can possibly be conveyed into coastal waters by spring water or into subsurface drinking water sources. Plants may be able to bioconcentrate some of the pollutants, possibly removing the pollutants from the soil and limiting their availability in the environment. Initially soil salinity of the dredged spoil will prevent the growth of plants, except for those with a high salt tolerance. The salt will be leached from the material by rainfall, eventually permitting the growth of some vegetation. Because of the potential adverse environmental effects, a suitable land disposal site should not be adjacent to potable groundwater sources and should not be in agricultural use if the material to be disposed of is potentially toxic. Erosion control methods will have to be employed to keep the material within the disposal site. If the dredged material is found to have significant amounts of toxic material that could form leachates, disposal may require use of an approved hazardous waste disposal site. No such sites are in Hawaii. Leachate tests will have to be performed on the contaminated dredged material to determine the potential of toxic materials leaching from the material. In Hawaii, leachates can percolate through the porous volcanic material and enter the groundwater, possibly contaminating drinking water sources or municipal water supplies. Encryptment, impervious linings and locating the disposal site close to the shore where the groundwater is unsuitable for drinking may be alternatives used in land disposal. The dredged material in Plans A and C consists of silty-clays, which are unsuitable as construction material, but may be used as sanitary landfill cover. The dredged material in Plan B consists of coralline material suitable for fill, which would be used to create the land areas along the breakwater.

5.11 Air Quality. Only Plan B has the potential for affecting air quality. The dredged material will be a source of dust until the areas are improved, or paved. The only habitated areas that will be affected are the homes at Baker's Beach and the hotels along Banyan Drive.

5.12 Noise Quality. None of the plans will result in a long-term increase in noise. The operation of equipment in the construction of the breakwaters and dredging and filling in Plan B will be temporary noise sources. The duration of construction is a gross measure to the extent of the noise pollution. (See Water turbidity, Table 2.) The only habitated area which will be affected are the homes along Baker's Beach and the hotels along Banyan Drive.

5.13 Historic Resources. Plans A and C were determined to have no effect on the breakwater, and Plan B was determined to have no adverse effect on the historic breakwater. However, both Plans A and B alter visual elements in Hilo Bay including the visual integrity of the breakwater.

6. PUBLIC INVOLVEMENT

6.1 PUBLIC INVOLVEMENT PROGRAM. The public involvement program has consisted of meetings and workshops with the public at large, meetings and workshops with members of the Federal, State, and County agencies, and the distribution of various reports and documents resulting from studies conducted under the Hilo Area Comprehensive Study to the public and agencies concerned with the progress of the study. In total, 10 public meetings were held including the initial public meeting in 1976, and eight technical studies have been released to the public. Tsunami hazards were the most frequent concern expressed by the public and the agencies. Surge (ship motion) in Hilo Harbor was the most frequent problem mentioned for deep-draft navigation, and beach restoration of the Bayfront beach was the most frequent recreational need. A public meeting was held in Hilo on 17 September 1981 to discuss the findings presented in the draft report and environmental impact statement. The public expressed a desire to improve water quality in the bay, but did not express a plan preference. The State Harbors Division expressed preference for Plan C.

6.2 REQUIRED COORDINATION. The following coordination must be completed with the following agencies:

a. Coastal Zone Management Act. If Plans A or B are recommended for implementation, a Federal Consistency Statement would have to be requested from the State of Hawaii, Department of Planning and Economic Development, Coastal Zone Management Office. A Federal Consistency Statement for Plan C was obtained from the State of Hawaii.

b. Endangered Species. If Plans A or B are recommended for implementation, the National Marine Fisheries Service would be requested to make a determination of project effect on the endangered humpback whale, endangered hawksbill turtle and the threatened green sea turtle. A determination of no effect on the threatened and endangered species was received for Plan C. Coordination with the National Marine Fisheries Service will continue concerning the ocean disposal of the dredged material under the Marine Protection, Research and Sanctuaries Act.

c. Marine Protection, Research and Sanctuaries Act, (Ocean Dumping Act). Bioassay and bioaccumulation test procedures need to be developed and approved by US Environmental Protection Agency, and the tests performed prior to ocean disposal of dredged material in Plans A and C. The results of the test must be coordinated with the US Environmental Protection Agency, which will decide whether or not to permit the ocean dumping of the dredged material. A public notice of intent to dispose of the dredged material in the ocean will be released following the completion of the tests.

d. State and County Approvals. The State of Hawaii, Department of Transportation, is responsible for obtaining all necessary local permits and approvals and satisfying the requirements of Chapter 343, Hawaii Revised Statues and EIS Regulations. The Federal EIS and CZM consistency request discussed the construction impacts and compatibility of the action to local coastal zone management policies, but did not address actions to be planned by the State.

6.3 STATEMENT RECIPIENTS. The following agencies and public-at-large were sent copies of the draft environmental statement and survey report. An asterisk following the name indicates that letters were provided in response to the draft reports.

<u>Federal Government</u>

- US Advisory Council on Historic Preservation
  - Washington DC Office
  - Western Project Review Office
- US Environmental Protection Agency
  - *Office of Environmental Review - no comment
  - *Region IX
  - Pacific Islands Office
- US Army Corps of Engineers
  - Coastal Engineering Research Center
- US Department of Agriculture
  - Institute of Pacific Islands Forestry
  - Soil Conservation Service
  - Hawaii District Office

Federal Government (Cont)

US Department of Energy
US Department of Commerce
Secretary of Environmental Affairs
National Marine Fisheries Service
Southwest Region Office
* Pacific Program Office
Office of Coastal Zone Management
National Weather Service, Pacific Region
US Department of the Interior
Office of Environmental Review
US Geological Survey, Hawaii Volcano Observatory
Secretary Field Representative, Pacific Southwest Region
US Fish and Wildlife Service
Regional Office
Pacific Islands Office
Endangered Species Coordinator
National Park Service
Office of Archaeological and Historic Preservation
Interagency Archaeological Service
Arizona Archaeological Center
Pacific Southwest Region Office
Hawaii State Office
US Department of Housing and Urban Development - no comment
* US Department of Health, Education and Welfare
US Department of Transportation
Federal Highway Administration - no comment
* 14th Coast Guard District
Cape Small, Hilo
Federal Maritime Commission

State Government

Governor George R. Ariyoshi
Hawaii Congressional Delegation
Department of Planning and Economic Development - Clearinghouse
Department of Health
Office of Environmental Quality Control
* International Tsunami Information Center
Department of Land and Natural Resources
* State Historic Preservation Officer
* Division of State Parks
Division of Fish and Game
Forestry and Wildlife Division
Forestry and Wildlife Division
Land Management Division
Water and Land Development Division
Conservation and Resources Enforcement Division
Hawaii District and Agent
Board of Land and Natural Resources
Marine Affairs Coordinator
* Department of Transportation
Highways Division
Harbors Division

State Government (Cont)

Department of Accounting and General Services
Attorney General
* State Department of Agriculture
Board of Agriculture
Public Utilities Commission
Hawaii State Library
Hawaii Island Branches
Department of Hawaiian Home Lands
Keaukaha School

County Government

Mayor Herbert T. Matayoshi
Hawaii County Council
Hawaii Legislative Delegation
Department of Parks and Recreation
Department of Planning
Planning Commission
Department of Public Works
Department of Research and Development
Department of Water Supply
County Fire Department
Department of Civil Defense

Organizations

Big Island Resource Conservation and Development Council
Big Island Casting Club
Association of Hawaiian Civic Clubs
Big Island Fish and Game Association
Conservation Council for Hawaii
Hawaii Island Chapter
Hale Consultants, Inc.
Hawaii Audubon Society
Hawaii Community College Library
Hawaii Electric Light Co.
Hawaii Island Board of Realtors
Hawaii Island Chamber of Commerce
Hawaii Tribune Herald
Hawaiian Civic Club
Hawaii Leeward Planning Conference
Hilo Transportation and Terminal Co., Inc.
Hilo Trolling Club
Hawaiian Paradise Park Corp.
Hilo Sailing Club
Life of the Land
Kalapana Community Association
Hilo Downtown Improvement Association
Kailua Trolling Club
Kawaihae Trolling Club
Japanese Chamber of Commerce and Industry of Hawaii

Organizations (Cont)

Kona Mauka Troller, Inc.
Kona Yacht Club
Mark's Boat Works
North Hilo Community Council
Moku Loa Sierra Club Group
Matson Navigation Co.
Puna Community Council
Suisan Co.
Save Our Surf
University of Hawaii
  Water Resources Research Center
  Library
  Environmental Center
* Hawaii Institute of Marine Biology
  Seagrant/Marine Advisory Program, Kona and Hilo Offices
Young Brothers Inc.
Wester Division Project Review, Lake Plaza South

Individuals

Mr, Alika Cooper
Mr. Dan Pakele
Mr. Dave Soderland
Mr. Edward Bumatay
Mr. Herbert Mann
Ms. Lei Keliipio
Mr. Paul Friesema

6.4 PUBLIC VIEWS AND RESPONSES

a. Federal Agencies.

(1) The National Marine Fisheries Service, Southwest Region, indicated that Plan C was not likely to affect the threatened green sea turtle, the endangered hawksbill turtle, or endangered humpback whale. Coordination will continue concerning ocean disposal of the dredged material.

(2) US Environmental Protection Agency (EPA). EPA had no objections to the proposed action and felt that the Draft EIS adequately sets forth the environmental impact of the proposed action, as well as reasonably available alternatives. EPA also indicated that Plan B would not comply with Section 404(b)(1) guidelines because the discharge of dredged or fill material occurred on a coral reef, a special aquatic site where the discharge of dredged or fill material is prohibited when practicable, less damaging alternatives are available, such as Plans A or C. However, Plan A involves discharge of dredged or fill material on Blonde Reef, and destroys less reef than Plan B.

b. State of Hawaii Agencies.

(1) Department of Land and Natural Resources, preferred Plan C provided efforts were taken to minimize sedimentation during dredging. Plan C was noted as not destroying the marine habitat in Hilo Bay.

(2) Department of Agriculture indicated that improvements to Hilo Harbor would benefit the agriculture industry.

(3) Department of Health, Office of Environmental Quality Control.

Comment: The Draft EIS does not reflect the participation of the State Department of Transportation as required by CEQ NEPA Regulations and Chapter 343, Hawaii Revised Statutes.

Response: The combining of the Federal and State EIS requirements is not mandatory under the quoted regulations. The State Department of Transportation could not participate in a joint EIS process within the schedule established by the Honolulu Engineer District. The Federal EIS could be adopted by the State Department of Transportation, particularly with respect to the implementation of Plan C, since the action does not require any particular, additive actions by the State to implement the plan.

Comment: In Section 6.2, Required Coordination, "State NEPA Requirements," should be changed to "requirements of Chapter 343, Hawaii Revised Statutes and the EIS Regulations."

Response: The change was incorporated as requested.

c. Other Organizations.

(1) University of Hawaii, Environmental Center.

Comment: The data base for Hilo is very small. Circulation, stratification and wave height data for a variety of conditions in Hilo Bay should be gathered before arriving at a decision to implement any structural changes.

Response: The data base used in the planning process is sufficient to make decisions concerning plan selection. As a result of the study, data on tsunami hazards, circulation, stratification and biology was compiled over several different seasons (See Bibliography. Neighbor Island Consultants, 1973; Resources Planning, Inc., 1977; Sunn, Low, Tom and Hara, 1977; U.S. Fish and Wildlife Service, 1977, and M&E Pacific, 1980). Previously, there was little or no data concerning Hilo Bay water resources.

d. No comments were received from the County of Hawaii agencies, special interest groups or individuals.

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LIST OF PREPARERS

Name	Expertise	Experience	Professional Discipline
Mr. Michael T. Lee	Biology	BA, Biology; 1 year Biologist, US Navy; 9 years EIS studies, Corps of Engineers.	Preparer, overall impact assessment.
Mr. William B. Lennan	Zoology	BA, Zoology; BS, 2 years post-graduate studies; University of Hawaii; 2 years fishery biologist, US Fish and Wildlife Service.	Fish and Wildlife assessment.
Dr. James E. Maragos	Marine Ecology	BS, Zoology; PhD, Oceanography; 2 years post-doctoral research; 8 years environmental consultant; 7 years EIS studies, Corps of Engineers.	Review, overall impact assessment. Corps NEPA Coordinator
Mr. David G. Sox	History and Culture	BA, MA Geography; 6 years research; 4 years EIS studies; Corps of Engineers.	Cultural and historical impact assessment.

INDEX, REFERENCES AND APPENDICES

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APPENDIX A

SECTION 404(b)(1) EVALUTION

DISCHARGE OF DREDGED OR FILL MATERIAL
FOR
DEEP DRAFT NAVIGATION IMPROVEMENTS

A. DISCHARGE OF DREDGED OR FILL MATERIAL, DEEP DRAFT HARBOR IMPROVEMENTS, SECTION 404(b)(1), FACTUAL DETERMINATION.

1. Special Aquatic Areas.

Sanctuaries and Refuges: None.

Wetlands: None.

Mudflat: None.

Coral Reefs: Portions of the discharge will occur on Blonde Reef, the major reef in Hilo Bay. Coral cover on the reef varies from 0-16% reflecting a decline in coral growth probably caused by the breakwater reducing wave energy and flushing on the reef, and increasing freshwater and sedimentation stress. Surveys suggest that the breakwater reduces water column mixing in the bay resulting in the development of a two-layered water body, where freshwater reduces water salinity to a depth of 10-20 feet in the bay. Reduced wave energy permits silt, carried into the bay by tributaries, to settle out on the reef, smothering benthic organisms, particularly coral. By contrast, portions of the reef outside of the breakwater have coral cover ranging from 40-70%. Effect: The discharge of dredged and fill material in Plan B results in the loss of reef habitat that could be revitalized if the breakwater were removed as proposed under Plan C.

Base Condition	Plan A	Plan B	Plan C
220 acres available inside the breakwater	6 acres covered. 4 acres rocky intertidal habitat created.	85 acres filled; 130 acres dredged. 7 acres of intertidal habitat created.	No effect

Riffle and Pool Complex: None.

2. Human Use Characterization.

Municipal Water Supply: Not applicable.

Recreational and Commercial Fisheries: Hilo Bay supports a large recreational shoreline fishery, and fishing sites are located all along the bay shoreline. Fishing within the discharge area occurs from Hilo breakwater and from the Baker's Beach shoreline. Recreational boaters possibly troll in the discharge areas. Common reef and nearshore coastal (neritic) fish are caught in the bay (see Attachment 1 for fish species list). The productivity of the fishery has not been measured, however, the fishery resource supports an estimated 2,100 local recreational shoreline fishermen, based on a 1972 survey (Hoffman and Yamauchi in Cheney, 1977). The State Division of Fish and Game indicated that 456 two-year permits for night fishing in the bay were issued between May 1975 and May 1976. Commercial fishing in Hilo Bay is no longer a significant industry. Effect: While the discharges will eliminate water area in the bay, the breakwater and fill structures will also provide new recreational fishing sites in the bay. The effect of the discharge of the rock used in constructing the breakwaters will probably provide fish and intertidal habitat partially offsetting loss of fish habitat. The discharge of fill in Plan B eliminates 85 acres of Blonde Reef, which may possibly reduce the available fishery resources in the bay.

Water-Related Recreation: Surfing, wading, swimming, canoeing and boating are significant recreational activities in Hilo Bay. Blonde reef is used by boaters and the Baker's Beach area provides open space, and wading and swimming opportunities. One surfing site in the bay is located at the tip of the breakwater. Effect:

Base Condition	Plan A	Plan B	Plan C
Boating	Breakwaters remove 6 acres of open water from boating use, and create new navigation feature in the bay.	Breakwaters and fill remove 85 acres of open water from boating use. The fill creates a new recreational boat	No effect
Wading, swimming and open space at Baker's Beach.	South breakwater may eliminate wading, swimming and open space by enhancing expansion of Hilo port at Baker's Beach.	No effect	No effect
Surfing at break-water tip.	No effect	Potential inter-ference with surfing.	No effect

Aesthetics: Hilo Bay's vista is dominated by the breakweater. Effect: The discharge will create new visual elements in Hilo Bay, except Plan C, which does not involve the construction of new structures in the bay.

Plan A - Adds two new breakwaters in the bay.

Plan B - Adds three new breakwaters and an 85-acre fill area in the bay.

Plan C - No effect.

National Monuments: None.

National Seashores: None.

National Wilderness Areas: None.

Research Sites: None.

National Historic Sites: Hilo Breakwater is eligible for inclusion on the National Register of Historic Places, based on its role in the development of Hilo port. The breakwater is also associated with events that facilitated the expansion of the railroad and port facilities in the Hilo area, the reestablishment of Hilo as the hub of transportation on the island of Hawaii, and the growth of Hilo. The breakwater is also the longest in the State of Hawaii, and has essentially maintained its physical integrity despite alterations to its original design, function and visual appearance. Effect:

Base Condition	Plan A	Plan B	Plan C
Historial significance.	No effect	No effect	No effect
Visual & physical appearance.	No effect	Trunk realigned. 85-acre landfill covers one side of breakwater. 3 new breakwaters adjoin existing breakwater.	No effect

3. Physical Substrate Determination.

Size Gradation and Coarseness: The Blonde Reef discharge site substrate consists of mud overlying coralline rubble and pavement. The Baker's Beach discharge site consists of sand and lava and coral cobbles and gravel. Effect: The discharges are associated with the construction of structures which will cover the substrate and raise the bottom elevations from below mean lower low water (MLLW) to about +10 feet above MLLW. Plan C involves no change to the existing condition.

Compaction: Not applicable. The discharge involves the construction of breakwaters and the fill area to be protected and confined by a rock revetment.

Bottom Elevation/Contour: See table below:

Base Condition	Plan A	Plan B	Plan C
Water depths at the discharge site.	0 to -36' below MLLW at Baker's Beach. -11 to -16' MLLW on Blonde Reef.	-11 to -42' on Blonde's Reef.	No effect
Condition after the discharge. Breakwater crest elevation.	+9.5' MLLW.	+10' MLLW.	No effect

Material Movement: Baker's Beach and Bayfront Beach are presently eroding. Effect: The construction of the south breakwater at Baker's Beach may reduce the rate of erosion along the beach.

Deposition: Not applicable.

4. Water Quality, Circulation, Fluctuation and Salinity Determination.

Current Velocity, Direction and Pattern: Presently a predominant surface outflow occurs in the harbor along the breakwater due to the discharge of groundwater and riverine water into the bay. Drogue studies indicate that current velocities vary from 0.03 to 0.19 knots. The ocean water lies beneath the surface, freshwater layer, and its movement is tidal dependent with no set current direction. Effect:

Plan A - Plan A will tend to isolate the inner harbor from the outer harbor with the construction of two breakwaters. The breakwaters may tend to further reduce mixing in the inner harbor and create a greater salinity gradient in the inner harbor. The outflow of freshwater from the inner harbor may keep silt-laden riverine water out of the inner harbor and slow sedimentation in the inner harbor.

Plan B - No change to the existing condition is anticipated.

Plan C - No effect.

Downstream Flow: Not applicable.

Normal Water Fluctuations: No estuarine tidal lags are evident in Hilo Bay and the discharges are not expected to interfere with normal tidal fluctuations.

Salinity Gradient/Stratification: A salinity gradient is measurable in Hilo Harbor to a depth of 20 feet at the mouth of the harbor and 10 feet over Blonde Reef. The gradient is related to the amount of groundwater and riverine water discharged into the bay and the percent of freshwater in the surface layer can vary between 25% in the dry season to 75% following a storm event. Salinity measurements in the bay vary from 32-34 parts per thousand in the bottom layer and 11-30 parts per thousand in the surface layer. The formation of the salinity gradient is partially attributable to the breakwater which reduces wave energy as a water-column mixing force in the bay. Mixing is dependent upon wind and tidal forces, and ship traffic in the bay. Effect:

Plan A - The construction of the inner breakwaters may increase the salinity gradient and the depth of freshwater influence in the inner harbor.

Plan B - No effect.

Plan C - No effect.

Potability: Not applicable.

Water Physical Characteristics: Water chemical and physical characteristics in Hilo Bay are dependent upon riverine and groundwater discharges into the bay. Wastewater discharges into the bay were removed. Effect: See Table A-1.

Pathogens/Biological Content: Fecal coliform mean concentrations (number per 100 ml) ranged from 10 to 239 and fecal strep mean concentrations ranged from 62 to 1480. The source of the fecal bacteria was the riverine and storm drainage discharges into Hilo Bay. Effect: Only Plan B involves an increase in the amount of storm drainage water entering the bay due to the creation of the 85-acre landfill.

Eutrophication: Not applicable.

5. Suspended Particulate and Turbidity Determination.

Turbidity: The waters in Hilo Bay are highly turbid due to the discharge of suspended material from Wailoa River and other drainage ways into the bay. Turbidity usually increases with the volume of water discharged into the bay. Ship traffic and periodic maintenance dredging (once every 10 years) also contribute to normal turbidity levels in the bay. During the dry season, turbidity is considerably lower than the wet season. High chlorophyll-a and zooplankton concentrations are principal turbidity causing material during the dry season compared with inorganic sediment during the wet season.

	Storm	Wet Season	Dry Season
Turbidity (NTU, mean values)			
Surface	7.82-22.3	2.92-7.52	0.56-1.67
Bottom	4.9-7.65	3.65-9.15	0.69-2.20
Total Suspended Molds (mg/l, mean values)			
Surface	9.30-75.4	6.43-17.3	no data available
Bottom	16.1-44.5	7.40-28.6	

Source: M&E Pacific, 1980.

Effect: The discharge of rock to construct the breakwaters in Plans A and B is not expected to result in a significant increase in turbidity. The discharge of fill related to Plan B has the potential for increasing water turbidity, however, the use of containment and settling basins will probably result in the discharge of effluent with suspended material concentrations below existing conditions.

6. <u>Contaminant Determination</u>.

Initial Evaluation:	Plan A	Plan B	Plan C
a. The material proposed for discharge:	Basalt rock.	Basalt rock and coralline material.	No discharge.
b. Source site:	Quarry.	Quarry and dredging Blonde Reef.	N/A.
c. Contaminants can flow into extraction site:	No.	Yes.	N/A.
d. The material proposed for discharge was previously tested.	No.	Yes--chemical constituents only.	N/A.
e. Can pesticides enter the extraction site.	No.	Yes.	N/A.
f. Spills or disposal of contaminants have been documented in the past.	No.	Yes.	N/A.
g. Natural deposits of minerals or other substances harmful to man are present at the extraction site.	No.	No.	N/A.

The sediments in Hilo Harbor are contaminated with chlordane, PCB and arsenic based on analysis by the State Department of Health. The coral on Blonde Reef is not expected to be contaminated, but the sediment in the harbor is contaminated and will be impossible to separate from the coralline material.

Findings:

a. The material proposed for discharge in Plan A is not contaminated consisting of basalt stone. The material proposed for discharge in Plan B consists of uncontaminated basalt stone and contaminated dredged material. The dredged material is suspected of being contaminated with arsenic, PCB and chlordane.

b. The material classification for the basalt stone is Category 5, Discharge without potential for environmental contamination. The material classification for the dredged material is Category 2, Open water discharge with level of contamination similar to the discharge site.

c. Further testing of the dredged material is required under Category 2. Test protocol requires a sediment analysis and water column elutriate analysis.

List of Contaminants to be Further Evaluated: The discharge of dredged material under Plan B for the landfill requires testing for arsenic, PCB and chlordane.

Results of testing will be provided, if Plan B is selected for implementation.

Zone of Mixing: Not applicable. The dredged material will be used for construction purposes and will be confined to the fill site by a rock revetment.

7. Aquatic Ecosystem and Organisms Determination.

Fishery resources which support a recreational shoreline fishery are identified in Attachment 1. Corals are major reef organisms, but do not dominate Blonde Reef. Coralline algae presently dominates the reef cementing coralline rubble and dead coral forming the reef foundation.

Rare/Threatened and Endangered Species: The threatened green sea turtle and the endangered hawksbill turtle have been seen near the breakwater and may enter the harbor while foraging for food. No nesting areas are found within the harbor or along the breakwater.

Aquatic Ecosystem Dependency: Fishery resource dependency on Blonde Reef is unknown, however, fish surveys indicate that the most fish species and the greatest number of fish were found on Blonde Reef in comparison to other areas in Hilo Bay. Effect:

Base Condition	Plan A	Plan B	Plan C
Blonde Reef discharge site:			
52-133 fish counted, 18-21 species represented.	6 acres of reef covered; 4 acres rocky habitat	85 acres covered; 130 acres dredged; 7 acres rocky habitat formed.	No effect.

Base Condition	Plan A	Plan B	Plan C
Blonde Reef discharge site: (cont)			
Threatened and endangered turtles.	No effect.	Possible effect by decreasing foraging area.	No effect.

The effect of reef loss on fishery opportunities and success is unknown, but loss of reef habitat could result in a reduced fish abundance in the bay. Plan B results in the largest loss of reef habitat in comparison to the other plans and could reduce recreational fishing success in the bay.

Determination: The discharge of armor units into the harbor under Plans A and C do not significantly degrade water quality or human uses of the water. The basalt rock is not expected to contain contaminants, cause prolonged water turbidity problems will significantly degrade the aquatic ecosystem even though a lost of reef area is anticipated. Plan B does significantly degrade the aquatic ecosystem with the loss of fishery habitat and could lower recreational fishing success. Water turbidity associated with the discharge of the fill material can be controlled with the use of settling basins; the returning water will probably contain less suspended material than the existing bay waters. In Plan B, the dredged material will probably be contaminated with arsenic, PCB and chlordane and should undergo elutirate and sediment analysis prior to discharge. The contaminants are found throughout Hilo Bay within the bay sediments and probably not within the dredged corraline material.

Material Proposed for Discharge:

	Plan A	Plan B	Plan C
Basalt rock	200,700 C.Y.	588,500 C.Y.	0
Dredged corralline fill	0	5,242,500 C.Y.	0
Dolos armor units			

ATTACHMENT 1

CHECK LIST OF FISH AND SHELLFISH TAKEN

BY FISHERMEN WITHIN THE HILO BAY SURVEY AREA

LOCAL/COMMEN NAME	SCIENTIFIC NAME	LOCATION BY REGION
Aholehole	*Kuhlia sandvicensis*	5,6,7,9,11,12,14,16,17
Aku	*Katsuwonus pelamis*	3
Akule (Aji)/Hahalalu	*Trachurops crumenophthalmus*	1,6,9,11,14
Amaama (mullet)	*Mugil cephalus*	5,6,7,8,9,13,15
Awa (milkfish)	*Chanos chanos*	1,7
Aweoweo	*PRIACANTHIDAE*	16
Ehu (red snapper)	*Etelis marshi*	4
Hihimanu (ray)	*DASYATIDAE*	11,14
Hinalea (wrasse)	*LABRIDAE*	9,16
Humuhumu	*BALISTIDAE*	16,17
Kaku (barracuda)	*Sphyraena barracuda*	1
Kawakawa	*Euthynnus yaito*	14
Kumu	*Parupeneus porphyreus*	1,4,11,14,15,16
Kupipi	*Abudefduf sordidus*	9,11,16,17
Lae	*Scomberoides sancti-petri*	9
Maiko	*Acanthurus nigroris*	16,17
Manini	*Acanthurus sandvicensis*	11,14,16,17
Mano (tiger shark)	*Galeocerdo cuvieri*	1
Mano kihikihi (hammerhead shark)	*Sphyrna lewini*	1,2,11,14,16,17
Maomao	*Abudefduf abdominalis*	15,17
Menpachi	*Myripristis spp.*	16
Moano	*Parupeneus multifasciatus*	1,14,16,17
Moi/moi-lii	*Polydactylus sexfilis*	3,4,5,6,7,14

TABLE VI (cont.)

LOCAL/COMMEN NAME	SCIENTIFIC NAME	LOCATION BY REGION
Nehu	*Stolephorus purpureus*	1,2,11,13,14
Nenue	*Kyphosus cinerascens*	14
Oio	*Albula vulpes*	1,5,6,9
Omaka	*Caranx mate*	1
Oopuhue (balloon fish)	*Arothron hispidus*	4
Opakapaka	*Pristipomoides microlepis*	4
Opelu	*Decapterus pinnulatus*	9
Pakii(flatfish)	*Bothus spp.*	15
Palani	*Acanthurus dussumieri*	9,12,13,16,17
Piha	*Spratelloides delicatulus*	16
Pualu	*Acanthurus xanthopterus*	1
Puhi (moray eel)	*MURAENIDAE*	14
Puhi (tohe--conger eel)	*Conger marginatus*	14
Taape	*Lutjanus kasmira*	1,2
Toau	*Lutjanus vaigiensis*	11
Ulua/Papio	*CARANGIDAE*	1,3,4,5,6,7,9,11,14,15, 16,17
Upapalu (cardinal fish)	*Apogon snyderi*	15
Weke/Oama	*Mulloidichthys samoensis*	1,11,12,13,15
Tilapia	*Tilapia spp.*	10
Oopu (goby)	*GOBIDAE*	5
Crab - Kuahono	*Portunus sanguinolentus*	3,4,6,7,15
Crab - Samoan	*Scylla serrata*	3,4
Opae (glass shrimp)	*Palaemon debilis*	7,8,10,15
Ula	*Panulirus spp.*	3,4,16,17
Taco (octopus)	*OCTOPODA*	4,16,17
Opihi	*Cellana spp.*	4,16,17

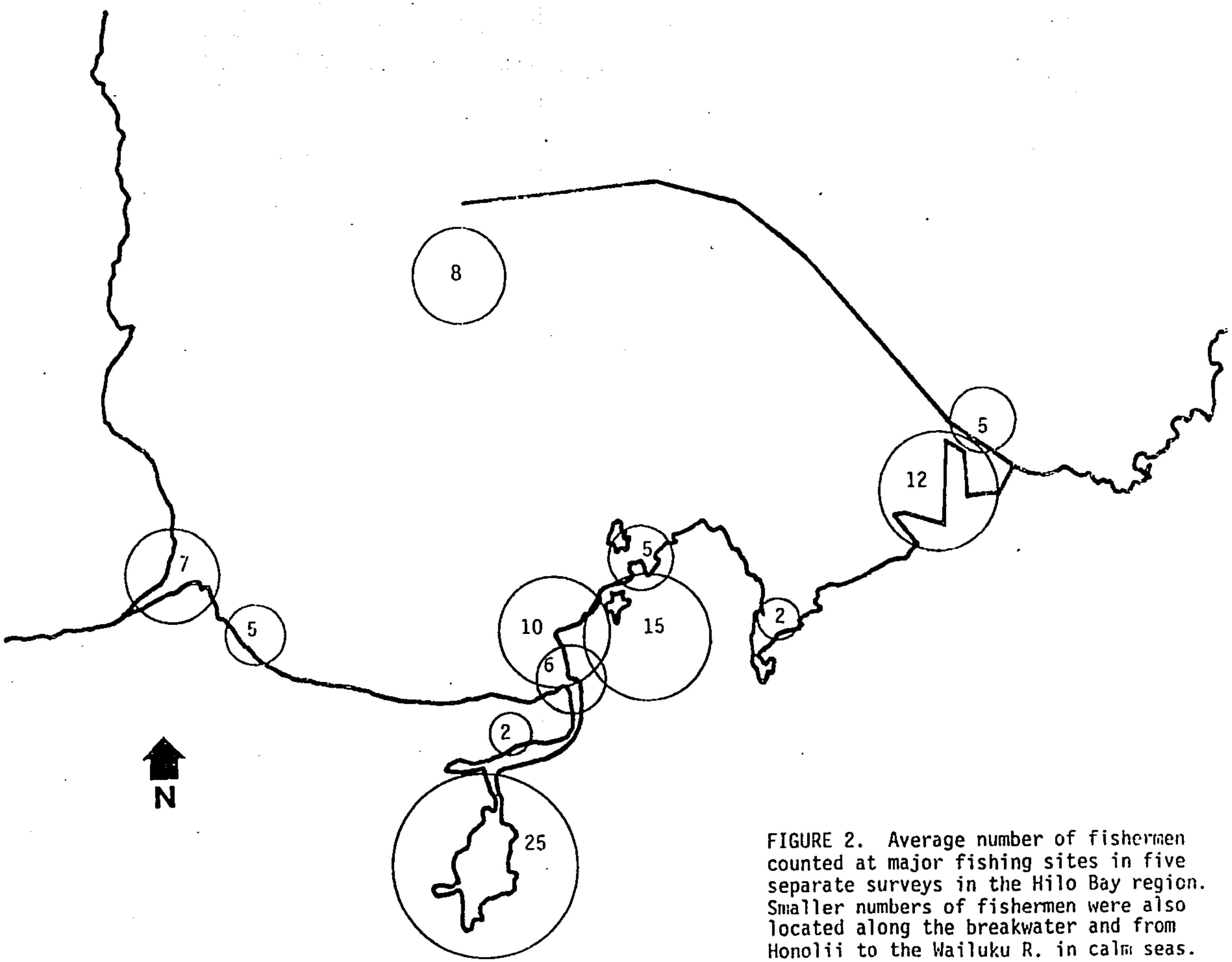


FIGURE 2. Average number of fishermen counted at major fishing sites in five separate surveys in the Hilo Bay region. Smaller numbers of fishermen were also located along the breakwater and from Honolii to the Wailuku R. in calm seas.

APPENDIX B

RECREATION AND NATURAL RESOURCES

1. Recreational Resources.

a. National Scenic and Wild Rivers. None present. Local land use planning documents propose the development of Wailuku River as a natural wilderness area and the development of Wailoa River and Waiakea Pond as park, open space.

b. National Trails. None present.

c. Natural Landmarks. None present.

d. National Shoreline Parks or Beaches. None present. Several State and County parks are present along the shoreline. While public access and use of the Hilo Breakwater is discouraged due to hazardous conditions, fishermen use the breakwater as a fishing site.

TABLE B-1. RECREATIONAL RESOURCES

Recreation Site	Acres	Ownership	Park Use
Wailuku River Mouth	-		Surfing
Mooheau Park	18.9		Beach (eroding)
Bayfront Park	6.8		Beach (eroding), canoeing, fishing
Wailoa River Park	146.0	State	General, boating, shoaling, river mouth
Liliuokalani Gardens and adjacent areas	20.5		General
Coconut Island	3.1		General, surfing
Banyan Drive Shoreline	-		Scenic
Reed's Bay	15.5		Beach (man-made) swimming
Baker's Beach		State	Beach (man-made)
Radio Bay		State	Boating
Radio Bay Park		State	General
Hilo Breakwater		Federal	Fishing

e. Water Contract Recreation. Principal water contact recreation activities in Hilo Bay include shoreline fishing, boating, wading and canoeing. Swimming is seldom observed possibly due to the highly turbid nearshore waters and concentrated mats of vegetative debris carried into the bay from the tributary systems. Six surfing sites were identified in Hilo Bay in the "Hilo Bay - a Chronological Study" in 1981. According to the Hawaii Chamber of Commerce, 1973, surfing demands have grown sufficiently to warrant investigations for increasing the number of surfing sites on the island. Fishing and boating are judged the most significant recreational activities. Canoeing is centered on use of the Bayfront beach and Wailoa River. Swimming is most prevalent in Reed's Bay.

(1) Fishing. Recreation fishing areas and resources in Hilo Bay are limited, popular, and need to be protected. Leisure time, recreational fishing is more important in Hilo Bay than commercial fishing as a source of seafood for local residents. Commercial fishing interests are principally interested in the offshore fishing grounds. The number of recreational fishermen in the Hilo Bay area is about 2,100 persons; 60% are shore fishermen, 5% are net fishermen, and the remainder utilize other fishing methods (Cheney, 1977). Favorite fishing sites, list of recreational fish species and general locations where the fish are caught are provided in Cheney, 1977. Fishermen believe that too many fishermen and poor enforcement of fishing regulations are partially responsible for over-exploitation. Fishermen are also competing for water use with canoe paddlers, surfers and boaters. Increasing the number of fishing sites and enforcing existing fishing regulations were believed to be beneficial to recreational fishing in Hilo Bay.

(2) Surfing. Five surfing sites are located in Hilo Bay (Kelly, 1981). One is located at Coconut Island, 2 at the Wailuku River mouth, one at Wainaku, and one at the tip of the breakwater. Kelly indicated that more surfing sites existed in the bay in the 1800's prior to construction of the breakwater.

(3) Beach Parks. The principal beach parks in Hilo Bay are Baker's Beach, Reed's Bay, Hilo Black Sand Beach, and Liliuokalani Gardens. Both Hilo Black Sand Beach and Baker's Beach are man-made. Also, portions of Reed's Bay were created from material dredged from Hilo Harbor turning basin during the period from 1925-1930. Hilo Black Sand Beach was formed by the natural accretion of eroded basalt material from the 1881 lava flow in the Wailuku River drainage basin. Black sand was mined from the beach in the 1900's. Both beaches are eroding. The creation of Baker's Beach appeared to have altered the dynamic equilibrium of the shoreline area and erosion is believed to be a natural process which reestablishes equilibrium. Erosion at Hilo Black Sand Beach appears to be related to the Hilo Breakwater (Reference M & E Pacific, 1980). The breakwater protects a portion of the beach which has remained stable. However, the exposed portion has eroded and beach sand is transported in an easterly direction. The breakwater appears to have eliminated the westerly component of the littoral transport.

(4) Boating. Wailoa River provides berthing for recreational and fishing craft. A State launch ramp is located in the river. Radio Bay and Reed's Bay are also used for berthing principally for sail craft and vessels with high superstructures which prevent use of the Wailoa River area. Boats using the Wailoa river must have an over-the-water height of less than 8 feet to pass under the Kamehameha Highway bridge. The existing facilities provide berthing for only 106 vessels. Only 4 transient berths are available.

2. Natural Resources.

a. Land Resources. The Hilo Bay shoreline is classified as Keaukaha Extremely Rocky Muck with 6-20% slope. The bay shoreline specifically consists of rocky headlands at Wailuku River, rock revetment and black sand along the Mooheau Beach Park, black sand at the Bayfront Beach park, rock headlands around Waiakea Penninsula, dredged coral fill at Baker's Beach and Reed's Bay and the developed port area. The harbor bottom consists of silty clays carried into the bay from upland areas by the Wailuku and Wailoa Rivers. Blonde Reef is principally a coralline reef area.

b. Prime and Unique Agricultural Lands. None present.

c. Natural Hazards.

(1) Volcanic Hazards.

TABLE B-2 RECORDED OR ESTIMATED NUMBER OF VOLCANIC ERUPTIONS ON THE ISLAND OF HAWAII DURING HISTORIC TIMES (1800-Present)

The summit and major rift zones of Mauna Loa and Kilauea volcanoes on the island of Hawaii have been very active during historic times, and volcanic activity is expected to continue through the foreseeable future.

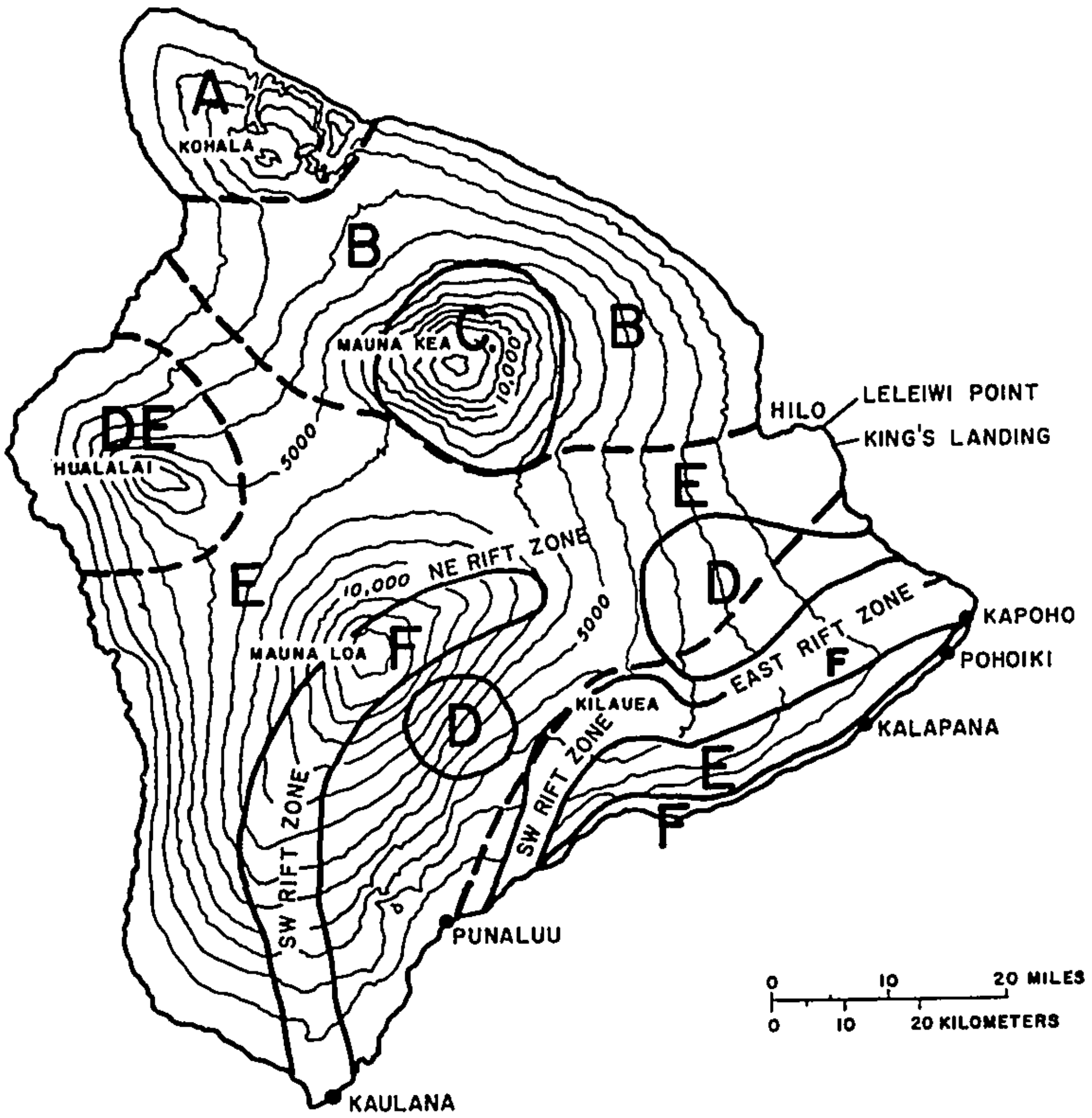
Volcano	Total Eruptions	Eruptions Outside the Caldera
Mauna Loa	30-40	About 15
Kilauea	40-50	About 25
Mauna Kea	0	-
Hualalai	2	-
Kohala	0	-

Adapted from US Geological Survey, 1974.

TABLE B-3. NUMBER OF ERUPTIONS ORIGINATING WITHIN HAZARD AREAS AND NUMBER OF TIMES LAVA FLOW COVERED LAND WITHIN HAZARD AREAS DURING HISTORIC TIMES (SINCE 1800) ON THE ISLAND OF HAWAII

Hazard Area	# of Eruptions	# of Lava Flows	% Land Covered by Lava
A	0	0	0
B	0	0	0
C	0	0	0
D	0	0	0
DE	1	2	6
E	1	35	15
F	80	More than 80	50

Source: US Geological Survey, 1974.



THE FIVE VOLCANOES THAT FORM THE ISLAND OF HAWAII: KOHALA, MAUNA KEA, HUALALAI, MAUNA LOA AND KILAUEA. CONTOUR INTERVAL 1,000 FEET. DASH LINES SEPARATE NAMED VOLCANOES. (USGS, 1974)

HAZARD DESIGNATION	EXPLANATION
F	AREA OF HIGHEST RISK WITH HISTORIC AND RECENT PREHISTORIC RECORD OF ACTIVE VOLCANISM, FAULTING AND SUBSIDENCE.
E	AREA SUSCEPTIBLE TO BURIAL BY LAVA FLOWS ORIGINATING FROM AREA F. DEGREE OF RISK GENERALLY DECREASES WITH DISTANCE FROM SUMMITS AND MAJOR RIFT ZONES.
DE	HUALALAI VOLCANO ONLY. LAVA BURIAL MORE FREQUENT THAN AREA D, BUT LESS THAN AREA F.
D	MODERATE RISK. NO HISTORIC OR RECENT PREHISTORIC LAVA FLOWS.
C	MAUNA KEA VOLCANO SUMMIT. SMALL RISK. ERUPTION FREQUENCY LOW, LAST ERUPTION 3000 - 5000 YEARS AGO.
B	NO ERUPTIONS DURING LAST 10,000 YEARS.
A	NO VOLCANIC ACTIVITY IN LAST 60,000 YEARS.

SOURCE: USGS, 1975

FIGURE B-1

Hilo is located in a high risk volcanic area (designated risk area E in U.S. Geological Survey, 1974; see Figure G-1). While the greatest danger to Hilo from volcanic activity is associated with eruptions within the northeast rift zone of Mauna Loa, the risk of potential damages and losses from lava flow and other hazards (ejecta, gases, subsidence and surface rupture) generally decreases down the volcanic slopes toward Hilo. Most lava flows from Mauna Loa have stopped short of the Hilo suburbs. Subsidence and surface rupture risks are considered low in Hilo, although earthquake property damage has occurred. An earthquake in 1975 caused about $4 million in property damage throughout the island. Since major structural damage risks are high, earthquake resistant structural design regulations are enforced.

(2) Tsunami and Riverine Flood Hazards

Hilo Bay is susceptible to tsunami and riverine flooding. Forty destructive tsunamis have reached Hilo since 1819, seven of which inflicted loss of life and property. The tsunamis of 1946 and 1960, resulted in the combined loss of 234 lives and damages in excess $52 million. Actions taken to lessen the impact of tsunamis included rezoning of vulnerable waterfront areas to open space and the adoptions of structural design codes to reduce future losses and damages. The highest tsunami runup elevation recorded was 35 feet in 1960. Riverine flood hazards are related to high intensity rainfall, overland sheetflow and undefined drainageways, the last of which is the consequence of the geological youthfulness of the region. The Alenaio Stream flood plain is the principal flood hazard area in Hilo.

d. Vegetation. No significant vegetation communities or species are found around the Hilo Bay shoreline, although the Wailuku River is planned as a natural wilderness area by local planners.

e. Wildlife.

(1) Endangered Species. The endangered Hawaiian coot was observed nesting in Mohouli Pond in Waiakea Pond by Shallenberger, 1977. The endangered hawksbill turtle and the threatened green sea turtle forage along the coastal areas and have been observed near the breakwater. The National Marine Fisheries Service (1981) indicated that Hilo Harbor is not a habitat on which the turtles depend for their continued existence, but that they may enter the harbor while foraging for food.

(2) The humpback whale seasonally migrates through Hawaiian waters and can be found around all the major islands from Hawaii to Kaula Rock during the seasonal migration. The whales begin to appear during November and leave the islands by June with the greatest number occurring during February and March.

The National Marine Fisheries Service indicated that 500-700 whales annually migrate through Hawaiian waters to mate, calve and nurse their young. The whales prefer relatively shallow water, usually waters less than 100 fathoms deep, and are particularly numerous on Penquin Banks, in the area between Maui, Lanai, Molokai and Kahoolawe, around the northwest tip of Hawaii and between Niihau and Kauai. However, they are consistently seen in small numbers in other areas of the Hawaiian Islands during the season. Herman (1981) suggests that the whales first arrive in Hawaii around the island of Hawaii and travel northward toward the islands in Maui County and continuing toward Niihau and Kauai, where they leave on their return to the northern summer feeding grounds. The relative concentrations of whales in the Hawaiian Islands is illustrated in Figure B-2 based upon information provided in 1976 and 1977 census (Wolman and Jurasz 1976, and Rice and Wolman, 1977). The National Marine Fisheries Service provided the following whale census in the Leleiwi Point area of Hawaii. The whales have not been seen in Hilo Bay.

TABLE B-4. WHALE SIGHTINGS OFF LELEIWI POINT

Year	# Whale Sighted
1976	12
1977	7
1978	5
1979	9

(3) Wildlife Refuges. No wildlife refuges are established in the area.

(4) Marine Sanctuaties. No marine sanctuaries are established in the area.

(5) Migratory Waterbirds. The Hilo Bay area is not a major area of concentration for migratory shorebirds or waterbirds. However, migratory and domestic ducks have been observed in Waiakea Pond during the winter seasons. The most common waterbird in the Waiakea Pond is the domestic mallard.

(5) Wetlands. No wetlands are located along the Hilo Bay shoreline.

(6) Estuaries. Reed's Bay, Waiakea Pond, Wailoa River and the Wailuku River form small localized estuaries. These estuaries are not listed on the National Inventory of Estuaries.

f. Marine Resources.

(1) Hilo Bay is biologically depauperate, possibly the consequence of freshwater, siltation and turbidity stresses. The breakwater reduces the wave energy and water transport into the harbor, possibly allowing increases siltation in coral areas and reduce the mixing of marine and freshwaters masses. Freshwater stress prevents the establishment and growth of benthic marine communities on the reefs, and poor light penetration in water limits photosynthetic activity. The silt areas lack a developed infauna (Reference M & E Pacific, 1981). No live organisms were found in benthic samples taken from the silt areas probably as a result of recent maintenance dredging in the harbor. Six samples containing live organisms were obtained from rocky coralline areas in the bay. Scour and freshwater stress may be factors limiting benthic development in the Wailuku River mouth area.

(2) Blonde Reef: Live coral cover based on a survey of 5 sites in Hilo Bay ranged from 1-16% attaining the highest cover on Blond Reef (16%). The areas around Coconut Island had a live coral cover ranging from about 1-10% (M&E Pacific, 1980a). The surveyed detected a decline in coral cover between 1977 and 1980 possibly attributed to large floods in March 1980. Coralline

algae, Porolithon, was more abundant than coral increasing its substrate coverage between 1977 and 1980. Porolithon is responsible for the consolidation of loose reef material and encrusting coral skeletons. Large dead coral heads on the reefs inside the breakwater suggest that the reef was once a viable ecosystem. Wave energy on the reef would have created a high energy environment that flushed silt from the reef and reduced salinity stress by rapidly dissipating freshwater concentrations before the freshwater could affect the reef area. The wave action would have also created a high dissolved oxygen environment, and surge and wave currents would have promoted excellent water circulation over the reef, creating favorable conditions for coral growth. Areas within the breakwater exposed to waves refracted around the end of the breakwater have flourishing coral communities. The dead coral mass does provide habitat for fish and invertebrates and are areas of richness within the bay. The number of fish observed on the hard substrate habitat ranged from 4-365 fishes representing 3-29 species. For comparative purposes, areas seaward and to the east of the breakwater had coral cover ranging from 40-70% and fish numbers ranging from 172-543 fish representing 36-39 species (M&E Pacific, 1980b). Plankton densities in Hilo Bay, based upon 300 measurements, were not considered significantly different from other areas in the State, but were similar to ocean areas.

g. Fisheries.

(1) Fishermen believe fish stocks in Hilo Bay are declining (Reference Cheney, 1977) and attribute this reduction to a variety of factors including over-exploitation, removal of juveniles by bait fishermen, mechanical sugarcane harvesting and chemical pollutants. Whether or not a decline has acutally occurred is unknown and the exact factors affecting fish abundance have not been determined. The inshore fish catch presently accounts for less than 10% of the total fish landings in Hilo Bay, and are represented by fewer species than offshore fish. This contrasts to earlier trends at the turn of the century, when inshore reef fish accounted for 50% of the total pounds of fish landed in Hilo Bay and represented more species caught than offshore fish. Nehu catches have declined and are presently insufficient to support a fishing fleet. The decline in nehu resources is attributed by fishermen to overfishing, nutrient and sediment loading and an overall decline of the tuna fishery. The Hawaii Island Chamber of Commerce, 1973, would like to see nehu of other bait resources improved in hopes of revitalizing the commercial fishing industry in Hilo. The principal nehu catch areas are located within the commercial port. Former baiting areas were along the Bayfront shoreline to Hoolii.

(2) The development of the bay as a commercial port, dredging and filling shoreline areas, and disposal of industrial and domestic wastes have affected the aquatic habitat and may have affected fishery resources. However, the long-term trend in fishing stocks and composition is unclear. Fishermen opinions concerning cause and effect relationships on local fishery stocks suggest that certain natural or man-related factors influence fish abundance and species, and the fishing methods used. For example, siltation probably fills habitat required by moi, aweoweo amd menpachi. Low stream flow and dry winters appear correlated to increased catch rates, but high stream flows usually correlate with increased papio catches. Murky water tended to increase ulua and moi catch rates, but reduced reef fish and nehu catches.

High waves are thought to clear out the mud and improve fishing. The canec plant discharge into Waiakea Pond were thought to improve fishing. Good crabbing along the bayfront was associated with abundant _Enteromorpha_ and _Ulva_ growth. Chlorine from the sewage plant discharge was believed to be the cause of decline in piha (_Spratelloides delicatulus_) abundance. Shutting down and cleaning the sugar mills have resulted in a decrease in papio, ulua and moi catch and in an increase in menpachi, aweoweo, aku and other reef fish catch. Trawlers no longer foul their lines on rafts of bagasse. Turbid waters reduced spearfishing success and probably accounted for reduced reef fish catches.

h. Harvestable Shellfish Beds. None present.

i. Water Quality.

(1) Water quality in Hilo Bay has improved over the long-term with the removal and treatment of agricultural, industrial and domestic wastewater discharges. The pollutant sources have included wastewater from sugarcane and canec processing operations, raw sewage discharges, periodic shipboard waste disposal, cesspool overflow and leachates, surface runoff from agricultural lands, a thermal discharge, fish wastes, and petroleum wastes. At present, the major, point source discharges in Hilo Bay are the municipal sewage treatment plant discharge outside of the breakwater in Puhi Bay, and the Hilo Electric Company's Shipman power plant thermal discharge (28 mgd) into Wailoa River. The only sugar mill discharge in the area is located 8 miles north of Hilo Harbor entrance at Pepeekeo. The principal nonpoint pollution sources in Hilo Bay are the surface runoff from agricultural lands and leachates from cesspools. Groundwater seepage and riverine discharge into Hilo Bay has a significant influence on bay water quality.

(2) Hilo Bay is a two-layered water body (M & E Pacific, 1980a) due to the discharge of 300 mgd of freshwater from Wailuku River and 700 mgd of groundwater into the harbor. The freshwater forms a distinct surface layer over the more saline bottom water. The surface layer persists throughout the year and is thicker in the wet season than in the dry season reflecting hydrologic conditions in the watershed. Salinity gradients are higher near the shore where groundwater discharges into the harbor and persist next to the breakwater, suggesting that the breakwater forms a barrier that inhibits mixing of marine and freshwaters.

(3) The predominant surface current direction is seaward out of the harbor. A continuous outflow occurs along the breakwater possibly as a result of groundwater outflow from Radio Bay. The surface current is dependent upon the influx of freshwater and the predominant wind direction. The influence of freshwater is measurable to a depth of 10 feet on Blonde Reef inside the breakwater and outside of the harbor mouth. In some areas the freshwater influence extends down to 20 feet. The depth of the freshwater influence generally reflects the low degree of mixing between the surface and bottom waters in the bay. The primary mixing force is provided by the wind with some mixing at the interface due to the shear force between the freshwater layer and the saline bottom water. Turbulence from ship traffic periodically mixes the two water layers. During certain periods (20% of the time) the prevailing wind direction is onshore retarding the outward flow of water on the surface. A two-cell circulation pattern was measured in 1973 (Reference Neighbor Island

Consultants, 1973), but this condition may be the exception rather than the norm. Subsurface currents are influenced by the predominant westerly offshore coastal current off Blonde Reef (M & E Pacific, 1980a). Subsurface waters flow into Hilo Bay at a depth of 20-40 feet along the western side of the harbor mouth. Water continuously flows out of the harbor along the eastern side of the harbor mouth.

(4) Water quality baseline data are incomplete to compare annual variations with the State Water Quality Standards. The problem is due to water quality monitoring patterned after standards which were later revised in September 1979. The existing data are not reported in the same units of measurements contained in the new standards, and were not collected at a frequency sufficient to determine compliance with the new standards. In some instances the constituents analyzed are not the same as those required by the standards. The new standards classify Hilo Bay (inside the breakwater) as an embayment with marine water standards for a wet and dry season. Other types of water qaulity standards are further provided for artificial basins, reef communities and soft bottom areas within Hilo Bay. Data collected between March and June 1980 in comparison with the State Water Qaulity Standards indicate that turbidity, nitrate plus nitrite and total phosphorus exceed the geometric mean standard, and values for suspended solids, total kjeldahl nitrogen and chlorophyll-a exceeded standard maximum values (M & E Pacific, 1980). In general, Hilo Bay is vertically stratified due to freahwater discharges from surface and groundwater sources. Nutrients concentrations do not limit phytoplankton growth and do reflect seasonal fluctuations related to surface runoff and groundwater influx. Water temperatures are warmer in the surface waters than in subsurface waters, but solar heating can warm subsurface waters when the surface outflow is retarded. Suspended solids and turbidity fluctuate with seasonal water runoff and do not appear related to phytoplankton density. Subsurface seawater pH values are normal for seawater conditions and are higher than the freshwater surface layer. Generally, pH values are high when photosynthetic activity increases. Chlorophyll-a concentrations also fluctuate seasonally, being lower in the wet season when light water-penetration is reduced and when water turbidity is higher due to increased suspended solids. Dissolved oxygen levels are near saturation on the surface and attain super-saturated conditions in areas of high photosynthetic activity. Dissolved oxygen levels were lowest near the silty bottoms of the inner harbor and in Wailoa River probably due to reduced mixing with surface waters, to organic loading from terrestrial sources, and to organic material in the harbor that settles out of the water column. Fecal strep and fecal coliform bacteria concentrations have decreased over the past years with the removal of the sewage discharges, and are presently influenced by riverine and groundwater discharges. Fecal strep bacterial tend to survive longer in Hilo Bay than other areas in the State due to the freshwater layer in the harbor.

(5) Sedimentation. Water qualtiy data indicate that sedimentation is a significant factor influencing water quality in Hilo Bay. The low wave energy environment created by the breakwater allows silt to settle out onto the coral reef environments smothering and destroying the reef ecosystem. The rate of sedimentation may be slow based on maintenance dredging records for Hilo Bay Harbor; approximately 54,000 cubic yards of material was removed from the harbor in 1977 reflecting the amount of material accumulated in the harbor since 1962. The estimated maintenance dredging cycle for Hilo Harbor is once every ten years based on past records. Silt is derived primarily from upland

erosion within the Wailuku River drainage basin. Based on Table G-14, the principal sources of silt are the agricultural areas and the areas around the summit of Mauna Loa. However, about 35,000 tons of silt per year are deposited into Hilo Bay from Wailuku River (Corps of Engineers, 1976). Based on average annual rainfall in the region, significant soil losses are related to severe storm or intense rainfall events which affect severe erosion areas rather than smaller daily rainfall events. The rates of sedimentation in the harbor may be lower than in the past due to volcanism depositing new lava over erodible soils and to the termination of the sugar mill processing wastewater discharge into the harbor. The lava flow of 1881 covered some of the erodible soil in the Wailuku River drainage basin, and Wainaku Mill discharged 20,000 tons of suspended solids a year into the bay until it closed in 1976.

TABLE B-5. LAND-USES AND EROSION HAZARD OF THE WAILUKU RIVER DRAINAGE BASIN

Land-Use	Acres	% Total Area	Estimated Erosion Damage (Tons/Acres/Year)
Urban	1,800	1.0	4
Sugarcane and Diversified Crops	3,900	2.5	7-11
Forest	77,500	46.5	0.2
Pasture	33,800	20.2	2-3
High Mountains Conservation	50,000	29.8	1-15

Source of Data: Hilo Comprehensive Study, Plan of Study, December 1976, Honolulu District, U.S. Army Corps of Engineers

(6) Sediment Quality. Pollutant discharge into Hilo Bay have left arsenic, PCB (Polychlorinated biphenyls), and pesticide contaminants in the bay sediments. A State Department of Health survey in 1978 indicated that arsenic, PCB and chlordance concentrations were found in significantly high amounts in Hilo Bay (State of Hawaii, 1978) in comparison with other sites surveyed in the state. The contaminants in dredged material may make the material unsuitable either for land or ocean disposal, and may require special handling or treatment of the material prior to disposal. Sand sediments from a shoal in the mouth of Wailoa river were found suitable for upland disposal following Environmental Protection Agency EP testing which indicated that pollutants did not leach from the sediment.

(a) Arsenic.

Based on the State survey, sediment samples from the Hilo Bay area contained total arsenic residues in concentrations ranging from about 22 ppm to 6370 ppm. A Canec plant, which manufactured canec boards from bagasse, discharged wastewater containing arsenic trioxide, a termicide, into Waiakea Pond.

Sediments form the pond contain total arsenic residues in concentrations of about 6370 ppm. Sediments from the mouth of Wailoa River contained 131 ppm total arsenic, and sediments from Hilo Harbor contained total arsenic concentrations ranging from about 33 to 104 ppm. Total arsenic concentrations from sediments obtained from the outer part of the harbor ranged from about 22 to 33 ppm. The analysis indicated that arsenic migrated from Waiakea Pond into the bay environment. Arsenic concentrations in other Hawaiian estuarine sediments ranged from less than 4 ppm at Manele/Hulopoe, Lanai to about 20 ppm in Kaneohe Bay, and may reflect natural levels in Hawaiian soils. Analysis of fish and crab tissue indicate that arsenic is not bioconcentrating in the species tested.

(b) PCB.

Out of ten sites sampled in the State of Hawaii only two, Hilo Bay, Hawaii and Ala Wai Canal, Oahu, had measurable concentrations of PCB. Concentrations of PCB in Ala Wai Canal sediment ranged from 200 to 740 ppb with a mean of 372.6 ppb. The mean PCB concentration in Hilo Bay sediments was 200 ppm. The mean PCB concentration for other sample sites was less than 200 ppb. Under the test procedure the detectable limit was 200 ppb. No concentration of PCB was found in 27 biota samples analyzed.

(c) Chlordane.

Hilo Bay sediments also contained measurable quantities of chlordane. The sum of the mean values of three deriatives of chlordane was 84.2 ppb and was one of four sites in Hawaii found to have chlordane present in the sediments. Sediment from six other sites contained no chlordane residues above the detectable limit of 10 ppb. The levels of chlordane residue in mullet flesh from Waiakea Pond ranged from 80-160 ppb. No mullet from Hilo Bay was analyzed. The mullet viscera contained a chlordane residue 3 to 4 times higher than the flesh. The mean concentration of chlordane residue in Hilo sediment were considerable lower than the range of mean concentrations of chlordane residue (about 296 to 567 ppb) found in the Ala Wai and Kapalama canals.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
300 ALA MOANA BOULEVARD
P.O. BOX 50167
HONOLULU, HAWAII 96850

ES
Room 6307

NOV 5 1981

Colonel Alfred J. Thiede
U.S. Army Engineer District, Honolulu
Building 230
Fort Shafter, Hawaii 96858

Re: Hilo Area Comprehensive Study - Deep Draft Harbor, Hilo, Hawaii

Dear Colonel Thiede:

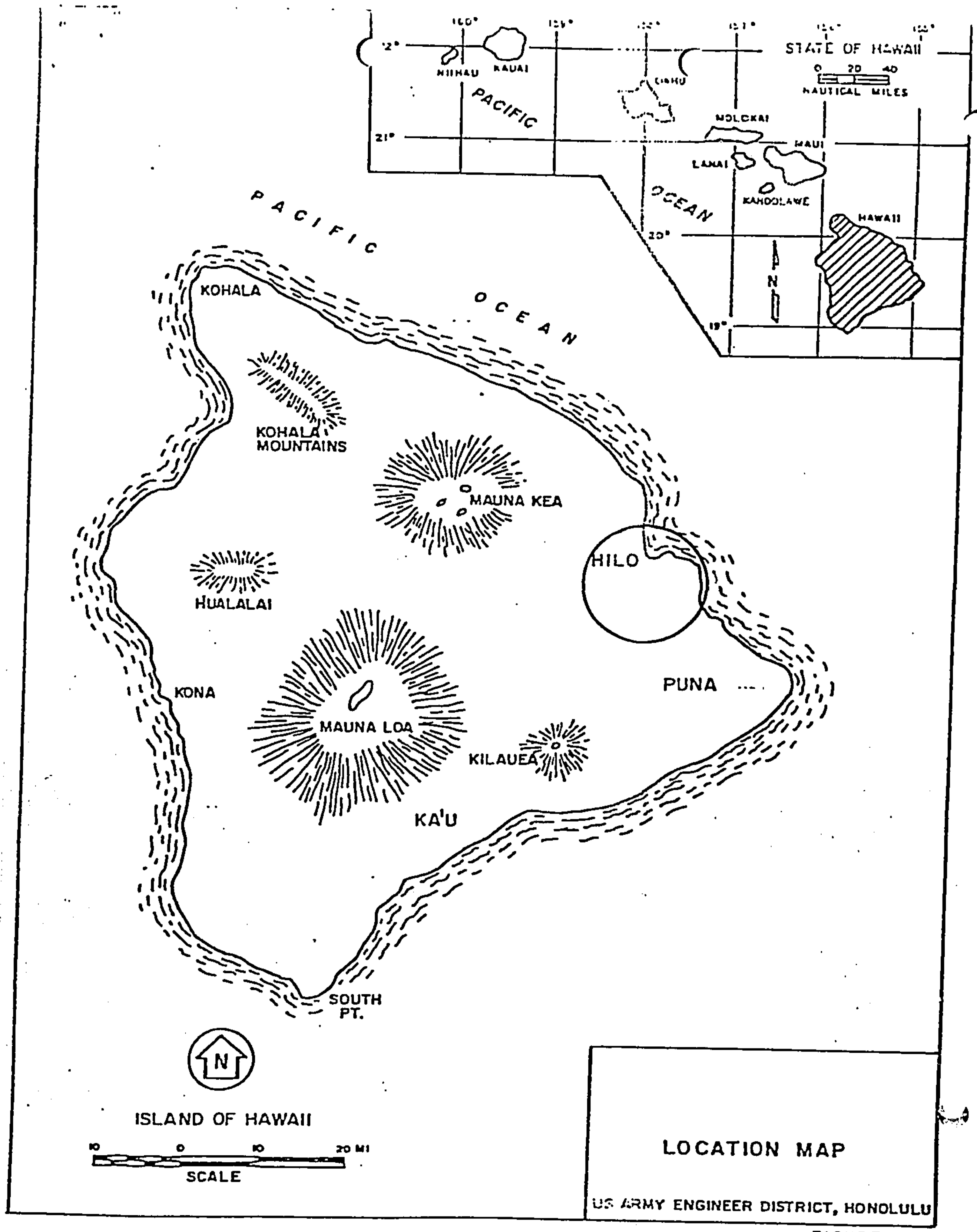
This is the U.S. Fish and Wildlife Service's Report regarding plans by the Honolulu District of the U.S. Army Corps of Engineers to improve the navigation in the deep draft commercial portion of Hilo Harbor, Hawaii County, Hawaii. This report has been prepared under the authority of and in accordance with the provisions of Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) and other authorities mandating Department of the Interior concern for environmental values. It is also consistent with the intent of the National Environmental Policy Act.

This study was authorized by Section 144 of the Water Resources Development Act of 1976 (Public Law 94-587). A large number of possible alternatives were considered by the Corps of Engineers. These were finally reduced to three structural alternatives and one non-structural alternative, which are considered in this report. The project has not yet been approved for construction. The goals of the Service in its study involvement were to: evaluate the impact each principal alternative would have on fish and wildlife resources, their habitat, and their utilization by the public; identify and evaluate the least environmentally damaging alternative; and recommend methods for preserving, compensating and enhancing these resources and mitigating unavoidable resource losses.

The Service's findings are based on project data provided by the Corps, prior to September 1, 1981; a project site inspection by Service biologists, and other relevant data concerning the project area. A prior Service report consisting of a Planning Aid Letter dated July 1, 1980, is superseded by this report. This document has been prepared by William B. Lennan II.

DESCRIPTION OF THE PLANNING AREA

Hilo Bay is on the northeast coast of the island of Hawaii (Figure 1). Hilo Harbor was constructed through placement of a 10,080 ft. rubblemound breakwater; by dredging of a 35 ft. deep entrance channel, and a 35 ft. deep harbor basin


STATE OF HAWAII
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KOHALA
KOHALA MOUNTAINS
MAUNA KEA
HUALALAI
HILO
KONA
PUNA
MAUNA LOA
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ISLAND OF HAWAII
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SCALE
LOCATION MAP
US ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 1

measuring 1,400 ft. by 2,300 ft. The entrance channel to the port enters the bay from the north between a coral reef (Blonde Reef) on the east and the west shores of Hilo Bay, then turns eastward through the bay to the harbor. The bay shoreline varies from steep cliffs on the west to relatively flat terrain on the south. The north and east sides of the bay are delineated by Blonde Reef and the harbor breakwater, which form an arc originating on the eastern shore. Waiakea Peninsula lies immediately east of the mouth of the Wailoa River. Kuhio Bay and Reeds Bay are to the east of the peninsula and Hilo Bay on the west side of the peninsula. The proposed harbor improvements all lie within the "inner harbor" which can be defined as the area east of an imaginary north-south line drawn from the breakwater tip to the Wailoa River (Figure 2).

Hilo Bay has circulation patterns based on tides, waves, wind and freshwater influences. A study by Neighbor Island Consultants (1972) described a two-cell circulation pattern in the harbor, with a net movement of water seaward. Water movement through the breakwater is believed to contribute to this flow and also cause surging within the deep draft harbor (Shallenberger, 1980). Replenishment of harbor waters is believed to occur by flow through the break-water and by currents from the western half of the bay. Replenishment of Reeds Bay and Radio Bay is believed to be primarily through extensive freshwater input from rivers and underground springs. The two primary freshwater drainages into the bay are the Wailuku River and Wailoa River. The tidal range in the bay is 2.4 ft.

Hilo Bay has been subjected to more than 150 years of direct and indirect modification resulting from human use of the bay and surrounding environment. Cultivation of peripheral lands increased the rate of siltation in the bay from several drainages. Wastewater and bagasse first entered the bay from nearby sugar mills in the late 19th century. Wastewater pollution from industry and untreated sewage began in the early part of the present century. In the last 20 years, direct dumping into the bay of sewage, industrial wastewater, sugar mill effluent and bagasse has ceased. Although water quality studies in the bay during this period have documented improved conditions for several parameters, localized problem areas still exist. Urban storm water discharge, terrigenous sediments, occasional sewer line breaks and fishing vessel bilge water discharge have acted together with poor circulation in some parts of the bay to maintain relatively poor ambient water quality. Low dissolved oxygen measurements indicate that organic loading is still too high to be compensated by slow water turnover of the bottom layer (Sunn, Low, Tom and Hara, Inc., 1977). Highest levels of fecal coliform and fecal strep are in areas influenced by discharges from the Wailuku River, Wailoa River, and Reeds Bay. However, decreased coliform levels in recent years result from discontinuing point discharges into the bay (Sunn, Low, Tom and Hara, Inc., 1977). Turbidity continues to be a periodically serious problem, particularly during high rainfall periods, when river-born sediment extends throughout the bay. Nutrient levels exhibit a similar periodicity and are attributed to storm drains, cesspool seepage and other sources. Studies in 1977 (Sunn, Low, Tom and Hara, Inc., 1977) indicated that nutrient levels generally exceeded the State water quality standards for total phosphorus and total nitrogen in Class A as well

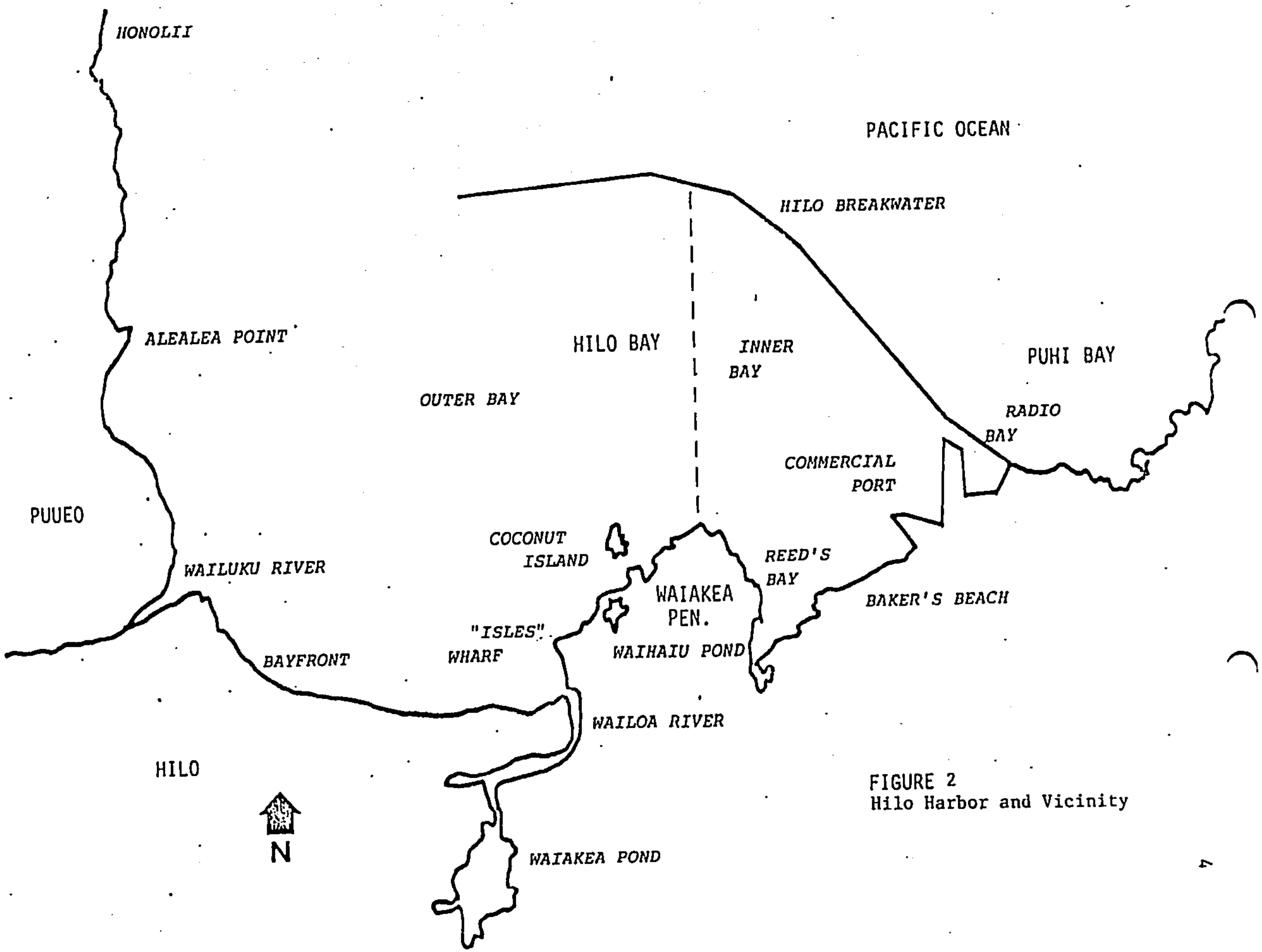


FIGURE 2
Hilo Harbor and Vicinity

as Class B waters. Under new State water quality standards, adopted September 1979, the Hilo embayment is placed into a new Class A, "underwater areas to be protected".

Salinity measurements throughout the bay show extensive year-round groundwater inflow, creating a stratified system inside the breakwater and throughout most of the bay. It is believed that the action of the tradewinds on the water's surface retards the seaward movement of surface water, thereby increasing the residence time of this layer, resulting in higher concentrations of freshwater derived nutrients, and allowing time for growth of high levels of photoplankton (Neighbor Island Consultants, 1978).

Marine biological conditions in Hilo Bay are generally characterized by low diversity and biomass of organisms relative to nearby coastal areas. Generally, macrofaunal distribution is determined by substrate type, freshwater influx, wave action, and light availability. On the basis of substrate types, Hilo Harbor can be divided into four major areas (Figure 3): silt and mud environment in deeper portions; silt, fine sand, and coarse sand along the western and southern shorelines between the Wailuku and Wailoa Rivers; the area seaward of the Wailuku River mouth which is influenced by freshwater, mud, silt and basalt river stones; and areas of past and present coral growth, including Blonde Reef, the shallow areas around Kaulainaiwi Island and Coconut Island, and the shallow areas seaward of Reeds Bay.

The first three substrate types are relatively depauperate from a biological standpoint. In general, shallow silt and sand bottoms provide a uniform habitat to which only a few organisms are suited. In contrast, the deeper silt and mud portions normally provide habitat for various crabs and shrimps. However, in Hilo Harbor, these organisms were not present, possibly as a result of dredging and anaerobic conditions caused by heavy organic loading (Sunn, Low, Tom and Hara, Inc., 1977). The hard substrate near the Wailuku River mouth also supports a sparse benthic community, consisting only of a few serpulid worms. This condition is probably related to freshwater exposure and heavy siltation.

In contrast, the living and dead coral formations provide a varied and relatively stable habitat, supporting a more diverse biological community. The inner portion of Hilo Bay, encompassing the area east of the Wailoa River and within the breakwater, contains the major portion of these coral formations. The presence of corals which appear to have died recently is significant and may indicate that water conditions are deteriorating. Nevertheless, dead coral blocks continue to provide habitat for fish and spiny lobsters (Sunn, Low, Tom and Hara, Inc., 1977).

Biological surveys in 1977 (Sunn, Low, Tom and Hara, Inc., 1977) included zooplankton sampling, and invertebrate and fish counts. In general, the plankton samples recovered from the inner portions of Hilo Bay contained greater numbers of zooplankton types compared to samples from the outer portion of the bay.

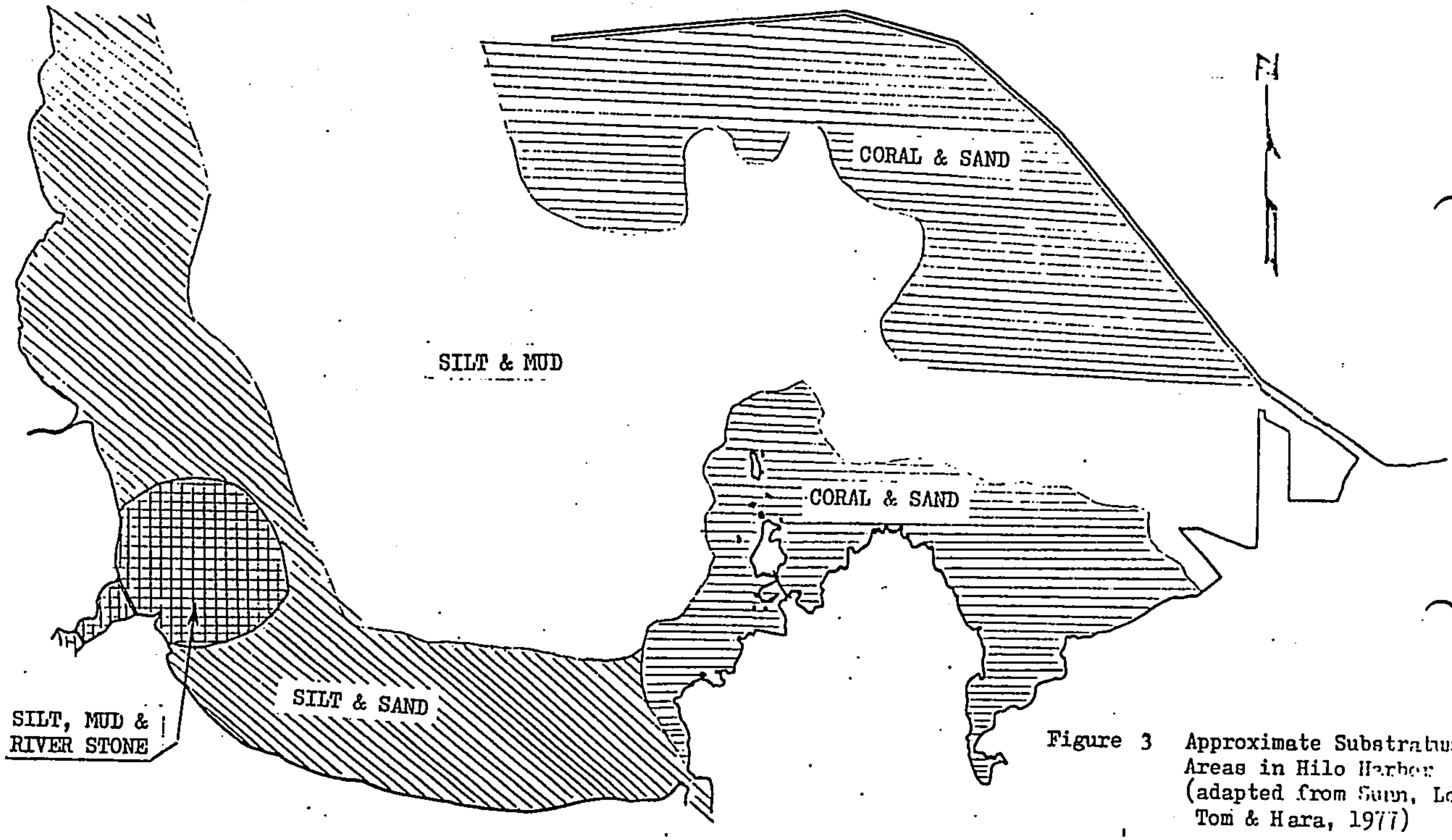


Figure 3 Approximate Substratum Areas in Hilo Harbor (adapted from Gunn, Low Tom & Hara, 1977)

Macroscopic invertebrates at sampling sites along the breakwater in the commercial port and at Baker's Beach included six species of coral and a variety of other animals (Table 1). The estimated percent coverage of the substrate by coral ranged from 4 to 44 percent, with the highest percent coverage in the vicinity of Blonde Reef (U.S. Fish and Wildlife, 1979).

The general biology of the inner harbor is described in an analysis by Neighbor Island Consultants (1973) as follows:

> "Low salinity areas, i.e., shoreline areas, are characterized by fresh water tolerant algal species such as Ahnfeltia, Cladophora, Ulva, and Enteromorpha, and sparse epifauna growth on the substrate. Rocks are typically encrusted with polychaetes, a few barnacles, the gastropods Nerita picea and Ostrea sandvicensis, as well as a few encrusting sponges. Corals are completely absent from these areas; however, fishes are surprisingly abundant. The bulk of fishes are juvenile manini and palani which appear to be adapted to decreased salinities. A number of pomacentrids and young goat fishes are also present in these areas.
>
> In areas of fluctuating salinity and crushed coral substrate, such as at Baker's Beach, the algal and faunal community is particularly sparse. Within the intertidal zone, rocks are never heavily encrusted, but instead bear a few barnacles, tubeworms, and sponges. The poor diversity of animals in these intertidal areas is probably affected by the low surface salinities encountered in these areas during periods of considerable fresh-water runoff and spring activity.
>
> The diversity of animals in the deep water silt substrate is very low, and limited to forms which are able to tolerate the harsh conditions. The only large animals endemic to this area were the portunid crabs, Portunus sanguinolentus and Podophthalmus vigil, and other small invertebrates such as polychaete tubeworms and nemertean worms. The larger gastropods, bivalves, sponges, bryzoa and corals, which are so characteristic of other subtidal areas, are completely absent from the deep silt substrate. Transitory species are occasionally found here.
>
> Shallow waters with silt bottoms have a paucity of plant and animal life. The area west and north of Coconut Island (to buoy 6) and the northwest portion of Reed's Bay are typical of this situation.
>
> The shallow waters with sandy bottoms, composed of crushed coral and mollusk shells, are typified by much of Reed's Bay and Baker's Beach. The algae and fauna community is not particularly rich in these areas. Algal growth is concentrated on the few scattered rocks, while fragments of algae are scattered throughout the bottom. Fishes are found in low numbers and are comprised of juvenile manini. The portunid crab, Portunis sp., are also common to this area.

Table 1. Benthic macroinvertebrates in Hilo Harbor from selected sampling stations, July 27, 1972 (from Neighbor Island Consultants, 1972).

Group	Description
Station: Breakwater (off tip)	
Coral	*Pocillopora damicornis*
Polychaeta	*Phyllochaetopterus verrilli* *Vermiliopsis hawaiiensis* *Hydroides novegica* *Salmacina dysteri* Spirorbinae - dextral and sinistral forms
Brachiopoda	*Terebratulina sanquinea*
Bryozoa	Cheilostomata (encrusting, rigid form)
Mollusca	*Conus lividus* *Hydatina* sp. *Spondylus hawaiiensis*
Crustacea	Small shrimp (Caridae) *Trapezea intermedia* Orange spotted Xanthid crab Orange/brown xanthid crab
Tunicata	*Didemnum candidum* *Polyclinum* sp. Yellow encrusting form (Didemnum)
Station: Mid-Hilo Bay	
Coral	*Porites lobata*
Polychaeta	Serpulidae - species not determined Spirorbinae - species not determined
Mollusca	*Mytilus* sp. *Ostrea sandvicensis*
Crustacea	*Balanus* sp. amphipods - gammarid type
Station: Breakwater (2/3 length from trunk)	
Porifera	red encrusting sponge

Group	Description
Hydrozoa	Colonial hydroid
Coral	*Pocillopora damicornis* *Pavona varians* *Montipora patula* *M. verrucosa* *Porites compressa*
Polychaeta	Serpulidae *Vermiliopsis hawaiiensis* *Spirorbis* sp.
Bryozoa	Black encrusting form Massive sheets of clear encrusting species
Mollusca	*Ostrea sandvicensis* *Hipponix* sp. *Mytilus* sp.
Crustacea	*Balanus* sp. *Hapalocarcinus marsupialis* (gall crab) *Trapezia intermedia* Orange Xanthid with brown chelae *Portunus sanguinolentus* *Podopthalmus vigil*
Echinodermata	*Tripneustes gratilla* *Centrechinus paucispinus* *Lytechinus verruculatus* *Holothuria atra* *Ophiocoma* sp.
Tunicata	*Didemnum candidum* *Styela* sp.

Station: Breakwater (1/3 length from trunk)

Hydrozoa	Colonia hydroid
Corals	*Pocillopora damicornis* *Montipora verrucosa*
Polychaeta	*Salmacina dysteri* *Spirorbis* sp. Dead serpulids

Group	Description
Arthropoda	F. Caprellidae
Mollusca	Ostrea sandvicensis (dead)
Echinodermata	Tripneustes gratilla
Bryozoa	V. rigid and purplish/black in color V. abundant

Station: Commercial Port Basin

Group	Description
Porifera	Dysidea herbacea
Polychaeta	Serpulidae - species not determined Terebellidae - species not determined Cirratulidae - species not determined Glyceridae - species not determined Eunicidae - species not determined
Bryozoa	Tubular, branched form
Mollusca	Ostrea sandvicensis
Crustacea	Balanus sp. Xanthid crabs (2 species) Portunus sanguinolentus
Tunicata	Ascidia sp. Microcosmus sp. Grey colonial form (Didemnidae)

Station: Baker's Beach

Group	Description
Porifera	Orange encrusting form (Demospongiae)
Hydrozoa	Encrusting colonial hydroids
Anthozoa	Epiphellia humilis
Coral	Pocillopora damicornis
Polychaeta	Protula atypha Spirorbis sp. Eunicids - errant forms
Mollusca	Acanthochiton sp.

Group	Description
Crustacea	Balanus sp. Portunus sanguinolentus Small shrimp (Caridea)
Tunicata	Grey, colonial form (Didemidae)
Station: Radio Bay Entrance	
Coral	Pocillopora damicornis
Polychaeta	Errantia - species not determined Hydroides norvegica Spirorbis (dextral and sinistral) Other small serpulids
Crustacea	Trapezia intermedia Trapezia digitalis

The substratum of Blonde Reef is composed primarily of dead corals interspersed with silt pockets. Viable corals, mainly species of Montipora, Porites, and Pocillopora, are found scattered throughout the area. The living coral heads are small and occupy less than 5 percent of the bottom area. Worn fragments of coral heads indicate that a far richer coral community existed at Blonde Reef in the past. Whether its decline is due to the presence of the breakwater, siltation from river runoff, or a combination of these and other factors, is unknown.

Blonde Reef is the area of the harbor which is richest in algae, invertebrates and fishes. Compared to outer reef areas and other enclosed bodies of water, such as Honaunau and Kealakekua Bays, Hilo Harbor is not particularly rich."

Based on previous studies, (Neighbor Island Consultants, 1973; Sunn, Low, Tom and Hara, Inc., 1977), relative ecological values are presented for Hilo Harbor in Figure 4.

The distribution of sportfish within Hilo Bay was correlated with habitat availability shown in substrate analyses (Cheney, 1977). Reef fish, including palani, kupipi, manini and puhi, were found in association with areas of past and present coral growth. Similarly, papio, ulua, akule, kumu, moana, oama, weke, toau, taape, aholehole, moi, mullet, oio, and shellfish were found in this vicinity and appeared to frequent the nearshore areas around the bay (Table 2). Based on reported recreational fishing catches, the silt/mud substrate, presently comprising nearly half the bay's marine habitat, appears to support little, if any, fishery resources. Cheney (1977) presents maps of fish species distribution and abundance within Hilo Bay. This was substantiated by diver observations during the marine survey performed by Bowers (in Sunn, Low, Tom and Hara, Inc., 1977).

Species of marine fishes caught by shore fishermen in the project area are presented in Table 3.

DETAILED PLAN DESCRIPTION

Alternative 1 - Inner Harbor Improvements (Plan A) (New Plan) (Figure 5)

This alternative consists of deepening the existing entrance channel and turning basin from -35 feet MLLW to -40 feet MLLW, constructing two new breakwaters, one 900 feet in length and the other 2,100 feet in length, and improving the dock fender system.

Approximately 551,400 cubic yards of silty-clay, contaminated dredged material will be disposed of in the ocean, depending upon the outcome of bioassay and bioaccumulation tests and approval of the action by the U.S. Environmental Protection Agency.

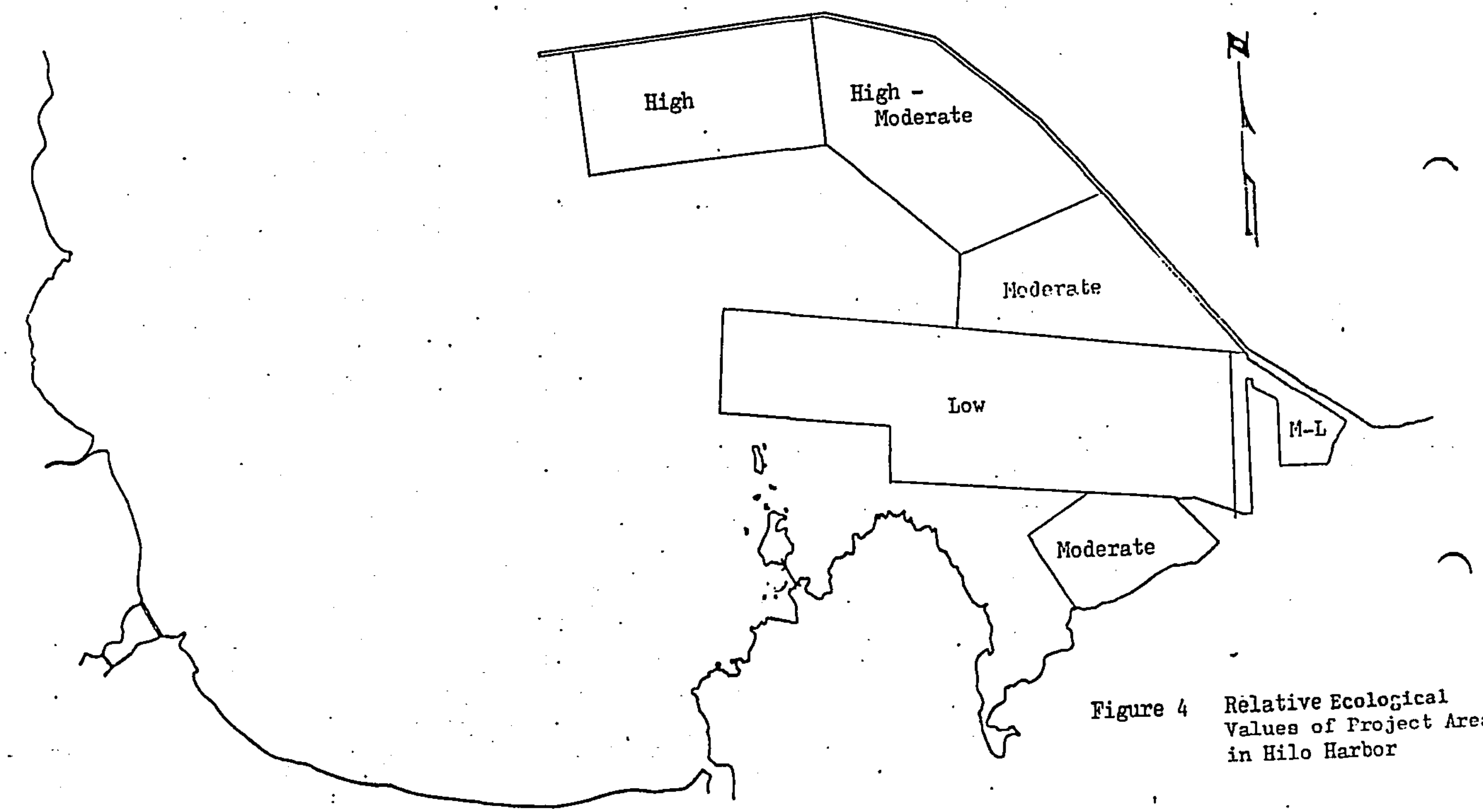


Figure 4 Relative Ecological Values of Project Areas in Hilo Harbor

Table 2. Fishes observed by divers in Hilo Harbor, June 1977 (adapted from Sunn, Low, Tom and Hara, 1977).

Scientific Name	BB	MB	BT
Acanthurus leucopareius	X		X
A. nigrofuscus	X		X
A. dussumieri	X		X
A. mata	X		X
A. triostegus	X		X
Zanclus cornutus			X
Ctenochaetus strigosus	X		X
Chaetodon fremblii			X
C. kleinni			X
C. auriga			X
C. unimaculatus	X		X
C. lunula	X		X
C. ornatissimus		X	
C. multicintus			X
C. miliaris	X		X
Centropyge potteri			X
Dascyllus albisella			X
Pomacentrus jenkinsi	X		
Chromis ovalis			X
Bodianus bilunulatus			X
Labroides phthirophagus			X
Thalassoma duperrey	X	X	X
Pseudojuloides cebasinus	X		
Stethojulis balteata	X		
Halichoeres ornatissimus			X
Paracirrhites arcatus			X
Cirrhitops fasciatus			X
Mulloidichtys flavolineatus			X
Parupeneus porphyreus	X		X
P. multifasciatus	X		X
Scarus sordidus	X		
Immature scarids	X		
Runula ewaensis	X		
Rhinecanthus rectangulus			X
Ostracion meleagris			X
Arothron hispidus			X
Canthigaster jactator			X
Lutjanus kasmira		X	

BB - Baker's Beach
MB - Harborside Mid-Breakwater
BT - Harborside Breakwater Tip

Table 3. Check List of fish and shellfish taken by fishermen within the Hilo Bay Survey Area (adapted from Resource Planning, Inc., 1977).

Scientific Name	BB	CP	RB
Kuhlia sandvicensis		X	
Trachurops crumenophthalmus		X	
Mugil cephalus	X		X
Dasyatidae		X	
Euthynnus yaito		X	
Parupeneus porphyreus		X	X
Acanthurus triostegus		X	
Sphyrna lewini		X	
Abudefduf abdominalis			X
Parupeneus multifasciatus		X	
Polydactylus sexfilis		X	
Stolephorus purpureus		X	
Kyphosus cinerascens		X	
Bothus spp.			X
Acanthurus dussumieri	X		
Muraenidae		X	
Conger marginatus		X	
Carangidae		X	X
Apogon synderi			X
Mulloidichthys samoensis	X		X
Portunus sanguinolentus			X
Palaemon debilis			X

BB - Baker's Beach
CP - Commercial Port
RB - Radio Bay

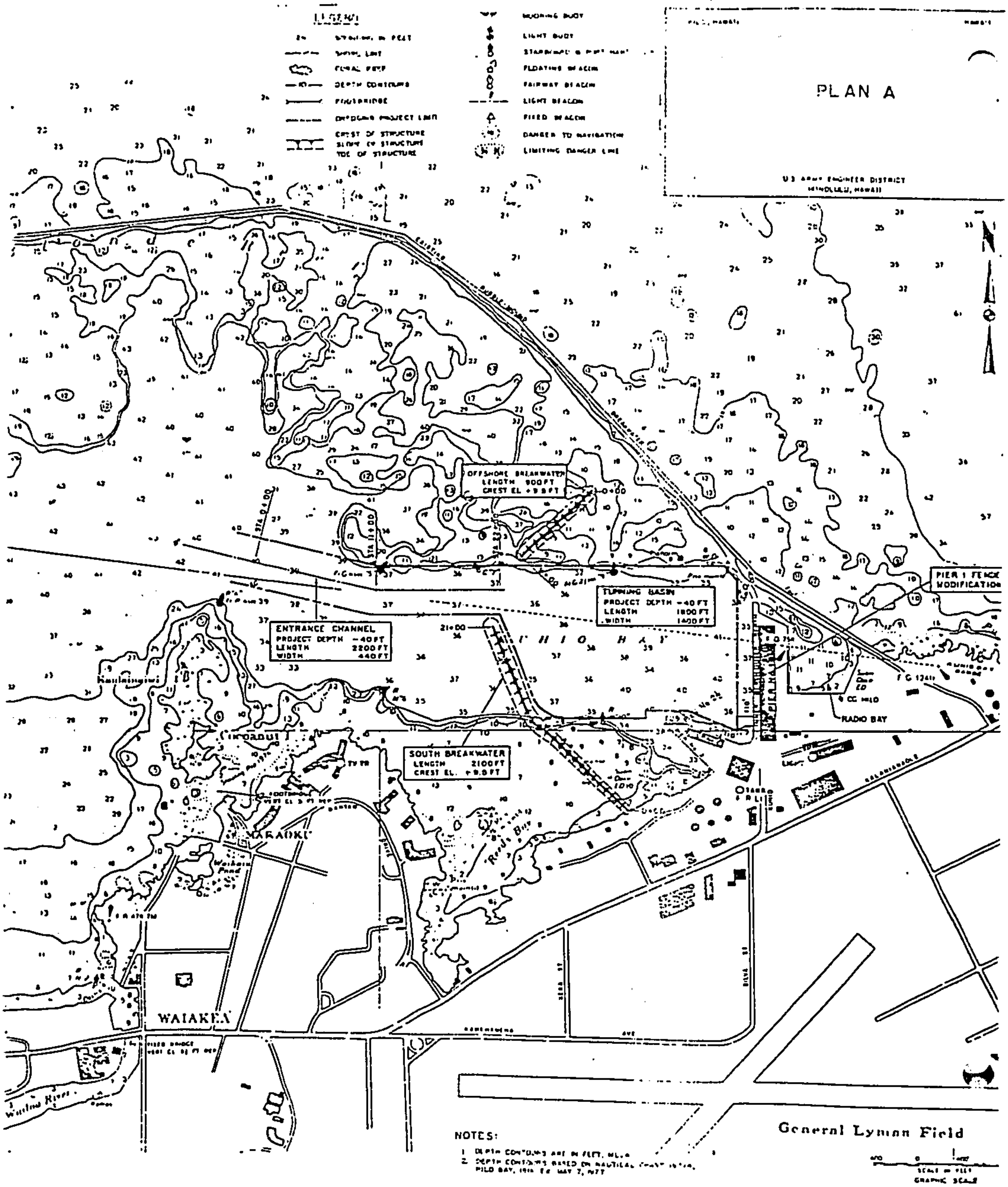

PLAN A
OFFSHORE BREAKWATER LENGTH 900 FT CREST EL +9.8 FT
TURNING BASIN PROJECT DEPTH -40 FT LENGTH 1800 FT WIDTH 1400 FT
ENTRANCE CHANNEL PROJECT DEPTH -40 FT LENGTH 2200 FT WIDTH 440 FT
PIER 1 FENCE MODIFICATION
RADIO BAY
SOUTH BREAKWATER LENGTH 2100 FT CREST EL. +9.8 FT
WAIAKEA
General Lyman Field
NOTES:

FIGURE 5

Alternative 2 - Chamber of Commerce Plan (Plan B) (Formerly Plan E) (Figure 6)

This alternative consists of a major realignment of the breakwater, expansion of the turning basin by dredging, and creating fill areas along the harbor side of the breakwater for container storage space, a small boat harbor, and a recreational park using the dredged material.

Alternative 3 - Changes to the Main Existing Breakwater (Plan C) (Formerly Plan D) (Figure 7)

This alternative consists of the deepening element of Alternative 1 and replacement of the existing buoy in the turning basin, improving the dock fender systems in Plan A, and construction of a new 2,000 feet breakwater. About 7,000 feet of the outermost portion of the existing breakwater will be removed down to -8 feet MLLW, or will be allowed to deteriorate naturally, or will be breached with the stones salvaged for use in constructing the new breakwater. The existing surface buoy in the turning basin would be replaced with a submersible buoy, which can be raised and lowered from the harbor bottom when needed.

Alternative 4 - Harbor Deepening and Dock Improvements (Plan D) (New Plan) (Figure 8)

This alternative consists of deepening the existing harbor and improved fender elements as described and discussed in Plan A, and the submersible buoy of Plan C. The Environmental Protection Agency requirements, as discussed in Plan A, will have to be fulfilled.

BIOLOGICAL & SOCIOECONOMIC EVALUATIONS

Terrestrial

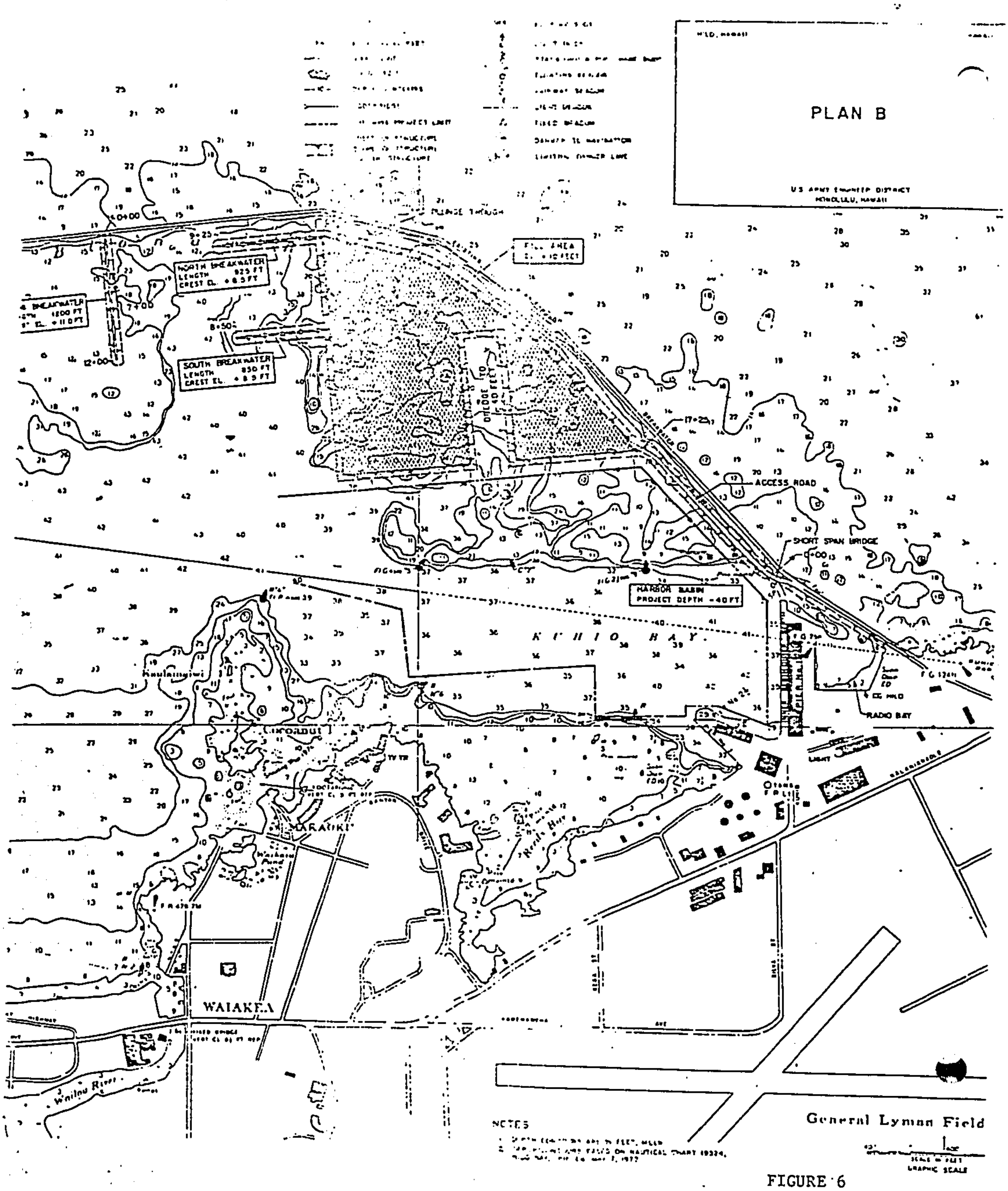
Terrestrial wildlife resources will not be significantly impacted by this project, since no construction, dredging or stockpiling of dredged materials will occur on land.

Aquatic

FUTURE WITHOUT THE PROJECT

Biological and Socioeconomic Assessment

The abundance and diversity of marine organisms in Hilo Bay is not expected to change dramatically within the forseeable future; and no dramatic change in the recreational fishing catch or in the commercial nehu catch is anticipated if the proposed action is not implemented. Continued degradation of water quality from allochthanous sources may affect both sport and commercial fishing unless appropriate measures are taken to improve circulation and/or reduce pollutant input to Hilo Bay.



PLAN B
NORTH BREAKWATER
LENGTH 825 FT
CREST EL. +8.5 FT
SOUTH BREAKWATER
LENGTH 850 FT
CREST EL. +8.5 FT
FILL AREA
ACCESS ROAD
SHORT SPAN BRIDGE
HARBOR BASIN
PROJECT DEPTH -40 FT
KUHIO BAY
RADIO BAY
WAIAKEA
Wailoa River
General Lyman Field
NOTES

FIGURE 6

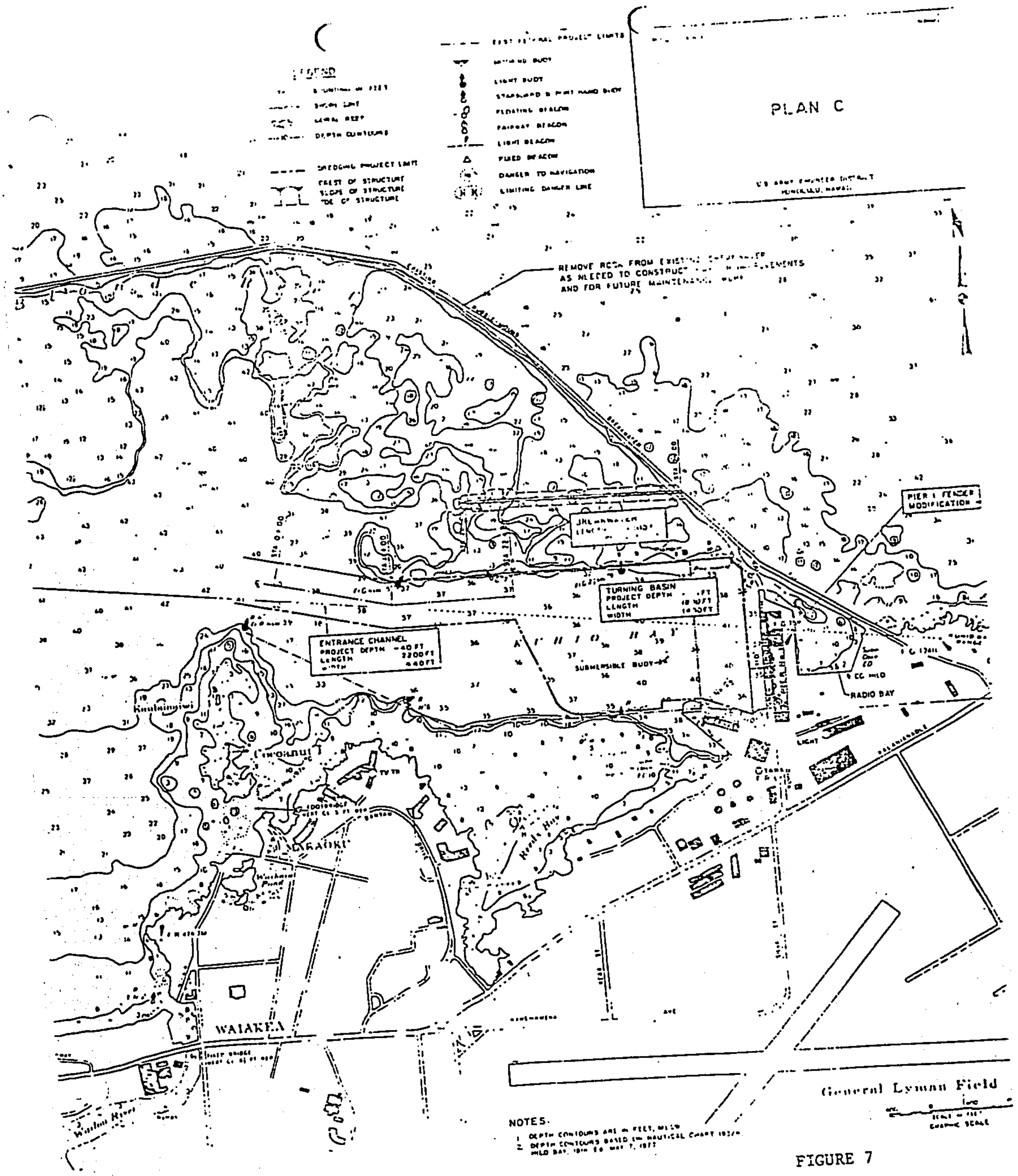

LEGEND
DREDGING PROJECT LIMIT
CREST OF STRUCTURE
SLOPE OF STRUCTURE
TOE OF STRUCTURE
LIGHT BUOY
FLOATING BEACON
FAIRWAY BEACON
LIGHT BEACON
FIXED BEACON
DANGER TO NAVIGATION
LIMITING DANGER LINE
PLAN C
REMOVE ROCK FROM EXISTING BREAKWATER AS NEEDED TO CONSTRUCT IMPROVEMENTS AND FOR FUTURE MAINTENANCE
PIER 1 FENDER MODIFICATION
TURNING BASIN
PROJECT DEPTH
LENGTH
WIDTH
ENTRANCE CHANNEL
PROJECT DEPTH -40 FT
LENGTH 2200 FT
WIDTH 440 FT
SUBMERSIBLE BUOY
RADIO BAY
LIGHT
Coconut
WAIAKEA
General Lyman Field
NOTES.
1. DEPTH CONTOURS ARE IN FEET, MLLW
2. DEPTH CONTOURS BASED ON NAUTICAL CHART
GRAPHIC SCALE

FIGURE 7

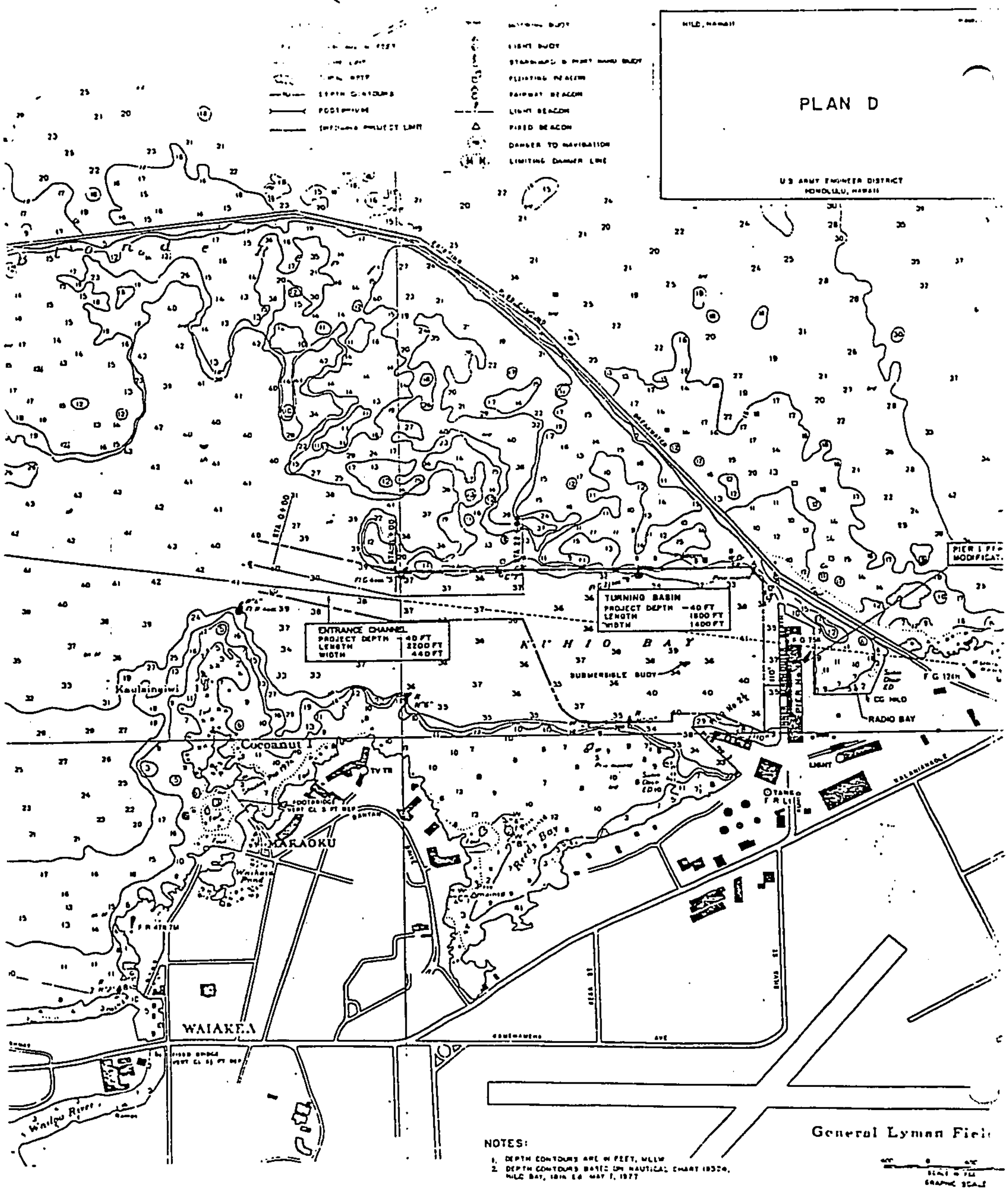

PLAN D
U.S. ARMY ENGINEER DISTRICT
HONOLULU, HAWAII
TURNING BASIN
PROJECT DEPTH — 40 FT
LENGTH 1800 FT
WIDTH 1400 FT
ENTRANCE CHANNEL
PROJECT DEPTH — 40 FT
LENGTH 2200 FT
WIDTH 440 FT
SUBMERSIBLE BUOY
RADIO BAY
PIER I FF
MODIFICAT
Kaulainaiwi
Cocoanut I
Reeds Bay
WAIAKEA
Wailoa River
General Lyman Fiel
NOTES:

FIGURE 8

FUTURE WITH THE PROJECT

Biological Assessment

Alternative 1 - Inner Harbor Improvement (Plan A) (New Plan)

Dredging the entrance channel and turning basin in Hilo Harbor would result in localized impacts on benthic fauna by excavation and by smothering with resuspended sediments. Sedimentation would most adversely affect sessile organisms such as corals, bivalve mollusks, sponges and tunicates. The dredge site, however, is relatively depauperate, and loss of the few invertebrates adapted to the silt/mud habitat is not considered significant. Recolonization by similar organisms would likely occur.

The two new breakwaters would destroy benthic organisms directly underneath, but would provide additional firm substrata for colonization by intertidal and subtidal organisms, thus increasing species diversity in that area of the Inner Harbor. The new breakwaters would further restrict circulation in the Inner Harbor, creating an increased biochemical oxygen demand (BOD), fostering the growth of some algae and invertebrates adapted to high nutrient loads and low oxygen levels, and excluding many resident, pelagic fishes due to low dissolved oxygen concentrations.

The improvement to the dock fender system would have no impact on the aquatic environment.

Socioeconomic Assessment

The overall long-term effect on recreational fishing from this alternative is hard to assess, but will probably be negligible. The breakwaters will provide additional topographic relief, but will also contribute to poor water quality due to decreased circulation. The net effect is undetermined.

Alternative 2 - Chamber of Commerce Plan (Plan B) (Formerly Plan E)

Biological Assessment

This alternative would eliminate virtually all of Blonde Reef by either dredging, filling, or sedimentation. This area has been identified as having the highest species and habitat diversity in the harbor. This alternative has the greatest adverse impact on fish and wildlife resources of any of the plans.

Socioeconomic Assessment

The elimination of a large part of the most valuable habitat in Hilo Bay would have a severe impact on the already impoverished recreational fishery. In addition, one of the major nehu fishing areas would be eliminated, thus adversely impacting the small commercial aku fishery. This action could also have substantial adverse cumulative impacts on fishery resources in light of other habitat modifications and degradation of water quality in Hilo Bay.

Alternative 3 - Changes to the Existing Breakwater (Plan C) (Formerly Plan D)

Biological Assessment

Breaching the breakwater or removal of armor stones as described will improve circulation and water quality in the harbor. Gradual deterioration of the wall will not lead to a significant water quality change in the near future, and will not impact the area biologically as by structure removal. Water quality outside the existing breakwater (along Blonde Reef) may be impacted by poor quality waters coming from the harbor if portions of the structure are removed. The construction of a new stub breakwater will eliminate about 1,000 sq. meters of moderately good harbor habitat. This will be mitigated somewhat by the creation of new rock habitat and improved water quality. Recolonization of low diversity areas in the harbor is anticipated unless substantial sedimentation of habitat occurs.

The impacts from dredging the entrance channel and turning basin are discussed under Alternative 1. DELETED

Socioeconomic Assessment

Improvement of water quality in the bay may result in an increase in fish abundance and diversity, thereby improving the recreational fishery. Removal of 7,000 feet of breakwater may however, eliminate a major nehu area, thus adversely affecting the small commercial aku fishery. Additionally, there is much public opposition to removal of the breakwater because of the tsunami hazard.

Alternative 4 - Harbor Deepening and Dock Improvements (Plan D C) (New Plan)

Biological Assessment

The impacts of dredging the entrance and turning basin are discussed under Alternative 1. There will be no impact associated with the submersible buoy or dock fender improvements.

Socioeconomic Assessment

This alternative will have no significant long-term effects on the recreational or commercial fishery in Hilo Bay. Dredging, by resuspension of organic detritus and nutrients, may result in short-term concentration of some predatory fishes at the dredging site.

SUMMARY OF IMPACTS

Aquatic

Benthic Fauna: Dredging in Hilo Bay would result in localized impacts on benthic fauna by excavation and by smothering with resuspended sediments. This would most adversely affect filter-feeding organisms such as bivalve

mollusks, tunicates, and sponges. Coral in the Blonde Reef area would also be
adversely affected by prolonged sedimentation. Most of the reef would be
destroyed by Plan B, drastically reducing the abundance and diversity of
benthic organisms in that part of the bay. Areas of the bottom now covered
with silty clay may support a more diverse benthic fauna after dredging only
if hard substrate is exposed. Breakwaters and other structures added to the
water would provide a suitable site for colonization by intertidal organisms.

Zooplankton: The zooplankton community within Hilo Bay is composed mostly of
copepods, with a few dominating species (Sunn, Low, Tom and Hara, Inc., 1977).
Adverse impact on zooplankton community as a result of increased turbidity
during dredging should be temporary. Impacts on species composition of the
zooplankton community cannot be predicted, but are directly related to the
fate of benthic, demersal and pelagic species with planktonic larvae within
the project area.

Algae: Algal growth is typically luxuriant along the Hilo Bay shoreline.
Locally high concentrations of Ulva sp. and Enteromorpha sp. reflect comparatively
high nutrient levels. Further increase in nutrient levels in the inner bay,
resulting from resuspension of sediments, discharge of shipboard wastes and
restricted flushing, may result in increased algal growth.

Fishes: Biological surveys of Hilo Bay show a diverse assemblage of fishes
only on comparatively undisturbed coral reef communities, particularly on
Blonde Reef adjacent to the existing breakwater. Plan B would have major
adverse impacts on fish in this area. Breakwaters in Plans A, B and C would
create suitable substrate for colonization by assemblages of some intertidal
algae invertebrates and fishes. However, Blonde Reef has an existing diversity
and abundance of fishes that would not be matched by post-construction conditions.
Motile species may be able to escape increased turbidity related to dredging.
Resuspension of organic detritus and nutrients may even result in localized
attraction of some fishes to the dredging site. Sedimentation would adversely
impact reef fish habitat on Blonde Reef and lead to reduced populations.

Endangered Species/Critical Habitats. No sanctuaries, refuges or critical
habitats will be affected by any of the proposed alternative harbor plans.
Two listed turtle species (Hawksbill Turtle, generic name - Endangered; Green
Sea Turtle, generic name - Threatened) may enter the bay occasionally, but it
is not likely that the condition of the bay waters is of long-term significance
to the survival of these species.

Plans under consideration for Hilo Harbor would have varied impacts on the
commercial and recreational fishery. Although there has been no documented
long-range adverse impact of maintenance dredging on nehu catch statistics, it
seems likely that the fishery in the immediate vicinity of the dredging would
be adversely impacted during the operation. This may have long-range impacts
on the small commercial aku fishery as this inner harbor is the only suitable
nehu fishing area when turbid Wailuku River waters enter the western part of
the bay (Cheney, 1977).

Placement of breakwaters will provide additional sites suitable for recreational fishing.

RECOMMENDATIONS

The Fish and Wildlife Service recommends that Plan E, the Chamber of Commerce Plan, be eliminated from further consideration because of the severe adverse impacts the plan would have on bay biota, sport and commercial fisheries.

If a decision is made to conduct harbor deepening and related improvements, we recommend that Plan D be considered for implementation. This plan appears to be the least environmentally damaging alternative which fulfills the basic goals of the project.

We appreciate this opportunity to assist you in project planning.

Sincerely yours,

Pacific Islands Administrator

Literature Cited

Cheney, D. 1977. Fisheries Assessment for First Spring Season Environmental Studies, Hilo Bay, Hawaii. Prepared by Resource Planning, Inc. for U.S. Army Corps of Engineers.

Neighbor Island Consultants, Inc. 1973. Baseline Environmental Investigation of Hilo Harbor. Prepared for U.S. Army Corps of Engineers.

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Sunn, Low, Tom and Hara, Inc. 1977. First Spring Season Environmental Studies, Hilo, Bay, Hawaii. Prepared for U.S. Army Corps of Engineers.

U.S. Fish and Wildlife Service. 1979. Biological Resources Report for Hilo Bay, Hawaii. Prepared for the U.S. Army Corps of Engineers.

APPENDIX C

SOCIAL RESOURCES

APPENDIX C - SOCIAL AND CULTURAL RESOURCES

A. SOCIAL RESOURCES.

1. Urban and Community Characteristics. Hilo's population growth has been attributed to a migration of people from the rural to the urban area and an influx of people from out of the County. Persons of Japanese ancestry form the dominant ethnic group in the area, but the Caucasian population has increased about 50% from 1950 to 1970, forming the second dominant ethnic group in Hilo. The number of persons of other ethnic groups have declined. The diversity of interests, education backgrounds and ethnic ancestry diffuse community cohesion, which is based principally on common community history and interests, ethnic backgrounds, and length of residences in the County. Most persons feel a strong tie to the County in which they live because of their preference for the geographical location.

TABLE C-1. POPULATION CHARACTERISTICS

Population	Hawaii County	Hilo City (South Hilo District)
1960	61,332 1/	31,553 1/
1970	63,468 1/	33,915 1/
1980	92,206 1/	42,320 1/
1990	105,100 2/	46,665 2/
2000	123,300 2/	Data not available

% Ethnic Composition (Hilo City) 4/

1970		
Japanese	37.5	43.4
Caucasian	28.8	28.0
Hawaiian	12.3	11.5
Others	21.4	17.1

Length of Residence

# Households (1976)		
	27,943 2/	12,751 2/

Data adapted from:

1/ State of Hawaii, Department of Planning and Economic Development, 1980
2/ State of Hawaii, Department of Planning and Economic Development, 1978
3/ County of Hawaii, Planning Department, 1979
4/ County of Hawaii, Planning Department, 1975
5/ Corps of Engineers, 1977

2. Economics, Education, and Cultural Opportunities. Hilo is the center of business, government and education in the County. The University of Hawaii was established at Hilo campus which is the center of higher education and cultural activities in the city. Government, trade and services are principal employers in the city with construction and manufacturing important secondary employers. Tourism is a powerful economic force, but inflation has been a principal factor affecting a decline in hotel occupancy rate and the number of visitors entering the County. Hilo Harbor is the principal deep draft port in the County handling the majority of petroleum, general cargo and agricultural products being shipped into the County.

TABLE C-2. INCOME AND EMPLOYMENT CHARACTERISTICS

	Hawaii County	Hilo
Income Distribution1/ (1975) # Families	19,514	8,278
Median Income (1975)	$ 12,028	$10,610-15,740

County Employment (1980) Distribution2/	Total Labor Force	Japanese	Caucasian	Hawaiian3/	Others
Employed	32,550	11,380	8,704	8,891	3,575
Unemployed	2,850	Unavailable			

Sources:

1/ County of Hawaii, Department of Research and Development, 1980

2/ State of Hawaii, Department of Planning and Economic Development, Data Book 1980. A Statistical Abstract, 1981

3/ Hawaiian and Part-Hawaiian

3. Life, Health, and Safety Serrvices

Fire. Hilo has four fire stations with three providing 24-hour service. Principal problems identified in the Hilo Community Development Plan, 1975, related to lack of parking at two stations, need for equipment to fight high rise fires and a new fire station in the airport and industrial port area.

Police. Hilo had a 90 member police force and an old building, which the 1975 plan indicated needed replacement.

Health. The main general hospital for the County is located in Hilo.

Solid Waste. Municipal home collection service was not provided by the County in 1975, and one sanitary landfill located in Hilo was operated by the County.

Utilities:

Water. Hilo's water distribution system consists of a number of reservoirs and a network of water mains. In 1975, the average daily consumption in Hilo was 3.7 mgd. The 1975 planning projections estimated an increase from 4.5 mgd in 1972 to about 5.7 mgd in 1980-1985. The Hawaii Water Resources Regional Study projected water demand by the year 2000 will be 65 mgd. Existing sources have the capability to produce 100 mgd and a potential capability of 2,300 mgd is available in the region.

Sewer. In 1975, the Community Development Plan indicated that Hilo had a primary treatment plan plant with an ocean discharge located outside the harbor in 50 feet of water. At the time Hilo generated about 7 mgd of effluent, but some homes were still using septic tanks and cesspools. The 1975 plan envisioned extending the discharge about 5,000 feet offshore and constructing a secondary treatment plant at Puhi Bay.

Power. Two power plants located in Hilo are basically fossil fuel plants and two others utilize hydropower. Improvements were needed to replace old facilities and lines, and to expand other facilities to replace loss generation. Geothermal power generation appears to be the most important alternate energy source besides other alternative energy sources such as bagasse and biomass conversion.

Landownership and Land Use. Hilo Harbor is dedicated to industrial and recreational use. The waters and major port facilities are owned and operated by the State of Hawaii.

SUPPORTING DOCUMENTATION

ENGINEERING, DESIGN AND COST

HILO HARBOR, HAWAII

ENGINEERING, DESIGN AND COST

TABLE OF CONTENTS

LIST OF PLATES

LIST OF TABLES

DESIGN ANALYSIS SECTION

1. GENERAL CRITERIA

a. FORMULATION AND ANALYSIS. The formulation and analysis of the alternative plans were based on the Waters Resources Council's Principles and Standards, and applicable Corps regulations and guidelines on planning process.

b. TECHNICAL CRITERIA. The following technical criteria were adopted for use in developing alternative plans for the general navigation facilities:

(1) Navigation improvements should be designed to accommodate a design vessel, whose length is 700 feet, beam is 92 feet and loaded draft of 34 feet, during all reasonable expected weather and sea conditions.

(2) The entrance channel should be of adequate depth and width to safely accommodate one-way traffic by the design vessel.

(3) The protected harbor basin should provide a safe maneuvering area for the design vessel, with convenient access to berth areas.

(4) Improvement plans should consider local plans for land use and port expansion.

c. FEDERAL DESIGN FEATURE. Federal design features include an entrance channel, turning basin and protective works such as breakwaters and stub breakwaters. All berthing and shoreside features necessary for a complete harbor facility would be provided by the State of Hawaii.

2. SITE LOCATION

a. HILO BAY. The study area was limited to the triangular shaped Hilo Bay at approximately 19.7° north latitude and 155.1° west longitude (Figure 2 of main report) on the northeast coast of the island of Hawaii. The south and east shores are relatively flat and at low elevations, while the west shore is rocky, nearly vertical cliffs. The entrance to the bay separates the cliffs and a coral reef, known as Blonde Reef, is about 1 mile wide with a maximum depth of 60 feet.1/ Blonde Reef extends about 2 miles northwesterly from the southeast side of the bay, with depths varying from 6 to 18 feet. The reef and the existing 10,080-foot long rubble mound breakwater affords storm wave protection to the inner bays. The inner bay includes Kuhio, Radio and Reeds Bays (Figure 3 of main report). Kuhio Bay serves as the deep draft harbor turning basin which is 1,400 feet wide, 2,300 feet long and 35 to 40 feet deep. The port area is located in the southeast end of the bay at the root of the 10,080-foot long breakwater. Two small rivers enter Hilo Bay: The Wailuku River adjoining the bluffs on the west, and the Wailoa River on the south. Published maps of the study area and vicinity are listed in the following tabulation:

Description	Prepared by	Chart No.
Hawaiian Islands	National Oceanic and Atmospheric Administration National Ocean Survey (N.O.A.A.)	19004
Island of Hawaii	N.O.A.A.	19320
Hilo Bay	N.O.A.A.	19324

b. PORT OF HILO. The port facilities at Hilo is on state-own land under the jurisdiction of the Department of Transportation, Harbors Division. The facilities at Kuhio Bay are used for handling general and bulk cargo, and the one at Radio Bay is used for mooring small transit vessels. Table D-1[2] is a tabulation of the physical characteristics of the state's facilities at the Port of Hilo.

3. CLIMATOLOGY

a. LOCAL CLIMATOLOGY. The average annual temperature at Hilo is 73°F. The highest average monthly temperature is 76°F in August and September and the lowest average monthly temperature is 71°F for January to March. Owing to the moderating influence of the bay and the ocean, extreme temperatures are of short duration and range from a record low of 53°F to a high of 94°F. Within the city of Hilo itself, average rainfall varies from about 130 inches a year near the shore to as much as 200 inches in mountain sections. The wettest part of the island, with a mean annual rainfall exceeding 300 inches, lies about 6 miles upslope from the city limits. Rain falls on about 280 days a year in the Hilo area. Temperature and precipitation data compiled by the Department of the Naval Oceanography Command Detachment, Barbers Point, Hawaii for the period 1946 to 1979 are shown on Table D-2. The wind velocity and direction table shows that winds approach Hilo Bay primarily from the southwest (SW) and west southwest (WSW) directions, rather than the typical northeasterly trade direction for the islands. Winds are predominantly from the SW and WSW during the night and early morning hours, with winds generally shifting to the typical trade direction by late morning. A wind diagram for the years 1965-1974 from the gage located at General Lyman Field is shown on Plate D-1.

b. TROPICAL STORMS AND HURRICANES. Although extremely rare in the Hawaiian Islands, tropical storms and hurricanes have and do, from time to time, affected the islands. Tropical storms are defined as having sustained wind speeds between 34 and 63 knots, while hurricanes are defined as storms with sustained wind speeds equal to or greater than 64 knots. Based on information from the U.S. Department of Commerce, Natural Oceanic and Atmospheric Administration (NOAA) National Weather Service, from 1950 to 1978 at least fourteen tropical storms or hurricanes have intruded within 500 miles of the state. So far, most of the threatening storms have weakened before reaching the islands and their effects have been minimal in most cases. Hurricane effects in the Hawaiian waters generally occur during the summer months.

4. WATER LEVEL AND CURRENTS

a. TIDES. The tidal data shown below were obtained from the U.S. Coast and Geodetic Survey and are referenced to Mean Lower Low Water (MLLW). All elevations in this appendix is referenced to MLLW datum.

1/ All elevations referenced to mean lower low water datum (MLLW), unless stated otherwise.

2/ Development Plans, Port of Hilo and Port of Kawaihae, Island of Hawaii, Tudor Engineering Company, August 1972.

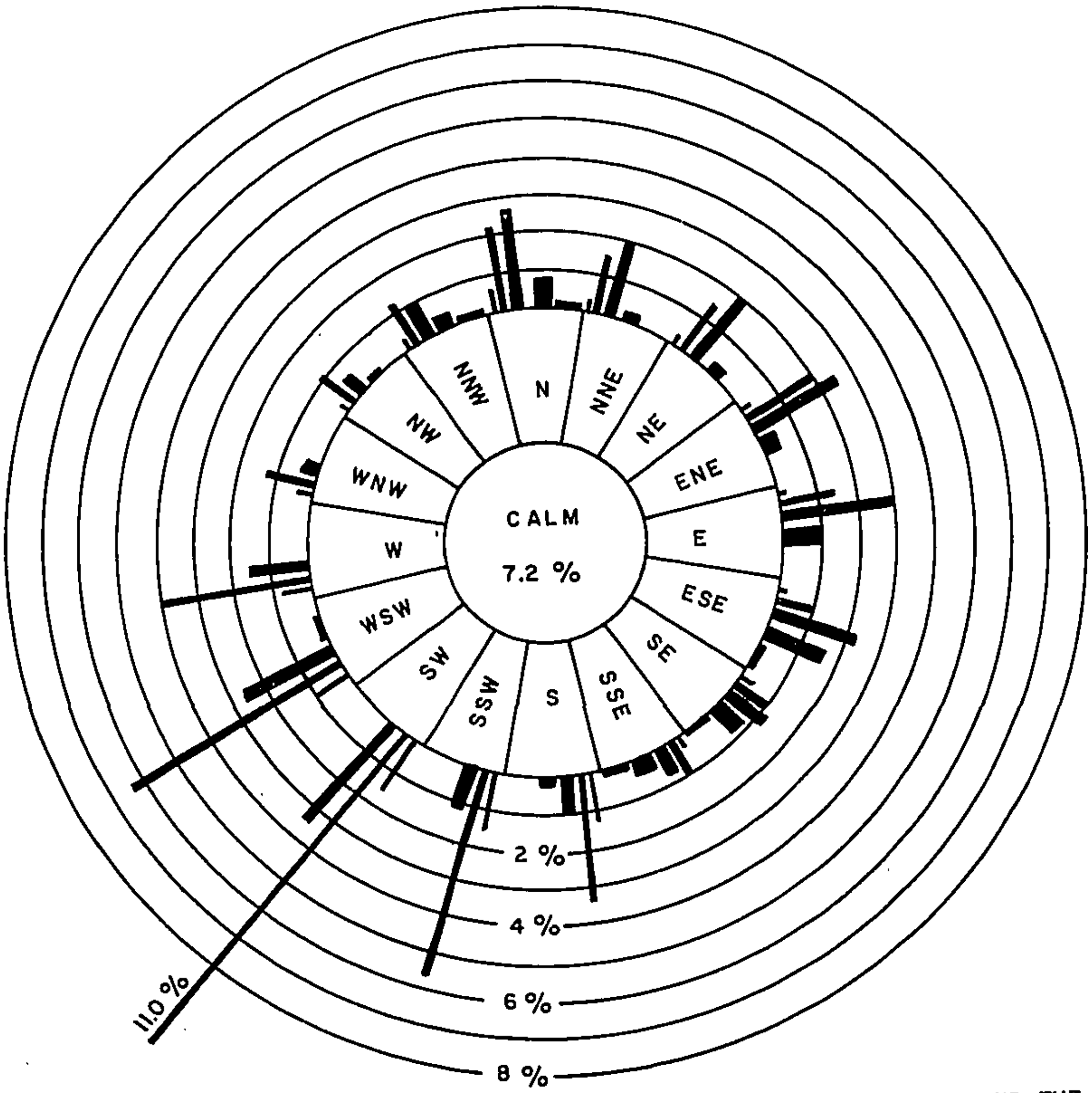
TABLE D-1. STATE FACILITIES, PORT OF HILO

Facility	Wharf or Berthing Description	Transit Shed	Paved Open Storage	Bulk Transfer Facilities
Pier 1	1275-foot concrete deck on concrete piles. Pier apron west of shed is 42' feet wide. Berthing depth is 35 feet.	150,800 square feet of steel frame shed with corrugated metal siding and roofing.	5.0 Acres	Sugar Molasses Fuel Oil Diesel Oil Bitumuls Water
Pier 2 & 2-1/2	Concrete deck on concrete piles. Usable berthing length is approximately 500 feet at Pier 2 and 170 feet at Pier 2-1/2. Berthing depth is 35 feet. Pier apron is 33 feet wide at Pier 2.	37,900 square feet of steel frame shed with corrugated metal siding. 9200-square-foot addition has corrugated metal roofing; remainder has built-up roofing.	3.2 Acres	Molasses Fuel Oil Water Cement
Pier 3	Concrete deck on concrete piles. Berthing length is 540 feet; berthing depth is 35 feet. Pier apron varies in width from 40 feet to over 100 feet.	None, but there is access to Pier 2 shed.	None, but there is access to Pier 2 & 2-1/2 open area.	Petroleum Products Molasses Water Aqua Ammonia
Radio Bay	450-foot concrete-capped sheet pile bulkhead. Fingers support boathouse for pilot boat and provide moorage for Coast Guard vessel.	None.	Minimum, but there is limited access to Pier 1 open.	None

TABLE D-2. HILO, HAWAII CLIMATOLOGY

	TEMPERATURE DEGS F							PRECIPITATION IN INCHES						
MON	AVG MAX	AVG MIN	AVG	EX MX	YEAR	EX MN	YEAR	AVG	MAX	YEAR	MIN	YEAR	24 HR MAX	YEAR
JAN	79	63	71	90	1977	54	1969	09.07	29.11	1949	00.36	1953	09.94	1949
FEB	79	63	71	92	1968	53	1962	12.90	43.66	1969	01.70	1963	15.70	1969
MAR	78	63	71	93	1972	54	1971	13.69	31.91	1948	00.88	1972	09.18	1953
APR	80	65	72	89	1978	56	1949	12.88	31.94	1963	02.93	1962	11.07	1971
MAY	81	65	74	94	1966	58	1947	10.07	25.01	1964	01.18	1945	10.26	1965
JUN	83	67	75	90	1969	60	1946	06.61	15.50	1943	02.46	1977	04.21	1978
JUL	83	68	75	89	1977	62	1970	09.54	14.89	1958	03.83	1975	05.42	1951
AUG	84	68	76	93	1950	63	1955	10.88	26.42	1957	02.66	1971	09.65	1970
SEP	84	68	76	92	1970	61	1970	07.44	13.63	1947	01.59	1974	06.02	1960
OCT	83	67	75	91	1976	62	1970	10.96	26.10	1951	02.40	1962	08.88	1951
NOV	81	66	74	88	1978	58	1948	13.77	27.03	1959	03.74	1943	15.59	1959
DEC	79	64	72	91	1977	55	1977	15.76	50.82	1954	00.77	1963	10.50	1946
					MAY		FEB			DEC		JAN		FEB
ANN	81	65	73	94	1966	53	1962	133.57	50.82	1954	00.36	1953	15.70	1969

GENERAL LYMAN FIELD
HILO, HAWAII



NOTE: THE PERCENTAGES AND THE DIRECTIONS ARE AVERAGES DURING THE 10 YEAR PERIOD, 1965 TO 1974 INCLUSIVE.

LEGEND:

- 0-3 KNOTS
- 4-6 KNOTS
- 7-10 KNOTS
- 11-16 KNOTS
- OVER 16 KNOTS
- —8%— TOTAL % OF YEAR

SOURCE – HONOLULU DLNR, DOWALD

HILO, HAWAII — HAWAII

WIND DIAGRAM

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE D-1

	Feet
Highest Tide Observed	3.8
Mean Higher High Water	2.4
Mean High Water	1.9
Mean Tide Level	1.1
Mean Low Water	0.3
Mean Lower Low Water	0.0
Lowest Tide Observed	-1.6

b. CURRENTS. The "Geological, Biological and Water Quality Investigations of Hilo Bay," prepared by M and E Pacific, Inc., Environmental Engineers for the Honolulu District Corps of Engineers in September 1980, provides a general understanding of the circulation pattern in Hilo Harbor. The following findings are presented:

(1) The freshwater discharge into Hilo Harbor have a profound influence in the circulation pattern by the creation of a vertical stratification of the water column.

(2) Wind stresses have significant influences on the surface layer.

(3) A net seaward flow occurs in the surface layer of the water column, while the bottom layer responds primarily to the tide.

(4) Subsurface flows at the harbor mouth are primarily influenced by tide. During periods of flood tide, subsurface flow is generally inshore (southerly) across the entire mouth of the harbor.

During periods of ebb tide, the subsurface flow is generally outward (northerly) across the entire mouth of the harbor.

Surface flows in the harbor are influenced primarily by the wind stresses and by the general outward gradient of the surface layer.

(5) Surface flows at the entrance to Kuhio Bay (turning basin) are influenced by wind stresses. The surface flow is generally in the direction of the wind and a counterflow exists at the 5-foot depth.

During flood tide, current speeds averaged 0.08 knots. During ebb tide, current speeds averaged 0.07 knots.

(6) Inner harbor (pier-Baker's Beach). The current speed in the subsurface layer averaged 0.05 knots during ebb and 0.02 knots during flood tide.

5. WAVE CONDITIONS.

a. WAVE CLIMATE.

Waves arriving at Hilo Bay are generated in the northeastern sector of the Pacific Ocean, ranging from the Aleutian Islands in the north to South America. Three primary wave types affect the study area. These four types are (a) the east-northeast trade waves, (b) the northern swell, (c) the tsunamis, and (d) hurricanes.

LOCAL WIND WAVES. East-northeast trade waves may be present throughout most of the year, but are most frequent between May and September, the summer season, when they usually dominate the local wave spectrum. They result from the strong trade winds blowing out of the northeast quadrant over long fetches of open ocean. Typically, these deepwater waves have periods ranging from 6 to 10 seconds and heights of 4 to 12 feet. Generally, east-northeast trade waves are present from 80 to 90 percent of the time during the summer season, and from 60 to 70 percent of the time during the remainder of the year.

NORTHERN SWELL. Northern swell is generated in the north Pacific Ocean by winter storms. Waves may typically have periods of 10 to 15 seconds, and heights of 5 to 15 feet. Some of the largest waves reaching the Hawaiian Islands are of this type. Northern swell usually occurs during the winter season of October through April.

TSUNAMI. Tsunami are impulse-generated water waves caused by catastrophic geological occurrences within an ocean basin. The orientation of the triangular-shaped bay at Hilo makes this port city very susceptible to tsunami attacks from the eastern half-circle of the seismic belt extending from the Aleutian Islands down to the west coast of South America. In several tsunami occurrences (Table D-3) at Hilo, the waves were transformed into bores which devastated large areas of the city and harbor.

TABLE D-3. LIST OF SIGNIFICANT TSUNAMIS SINCE 1946 5/

Date	Origin of Tsunami	Distance and Direction from Hawaii	Time of Arrival and Travel Time	Largest Wave Reported (Feet)
1 Apr 46	Aleutian	2000 nautical miles due north	Hilo 0645 4 hrs 55 min	30
4 Nov 52	Kamchatka	2600 nautical miles northeast	Hilo 1335 6 hrs 37 min	12
9 Mar 57	Aleutian	2000 nautical miles northwest	Hilo 0911 4 hrs 49 min	14
22 May 60	Chile	6600 nautical miles southeast	Hilo 1024 14 hrs 47 min	35
28 Mar 64	Alaska	2350 nautical miles north-northeast	Hilo 2300 5 hrs 24 min	10
29 Nov 75	Local	--	Hilo 0512 24 min	8.5

The most recent tsunami, which occurred on 29 November 1975, was unique because it was generated locally by a large scale land subsidence which occurred during an earthquake centered off the southeast coast of the island

5/ Loomis, H. G. 1976 Tsunami Wave Runup Heights in Hawaii, HIG-76-5, Hawaii Institute of Geophysics, University of Hawaii, Honolulu.

of Hawaii. This earthquake measured 7.2 on the Richter scale. The tsunami caused runups of about 10 feet along much of the Hilo District. In Hilo, the water level dropped with the recession of the first tsunami. The USS Cape Small, a Coast Guard cutter moored in Radio Bay, settled to the muddy bottom and began to list to one side. A series of waves surged in and out of the bay at approximately 15-minute intervals, smashing some small boats and washing others into docks; four boats were sunk and three damaged.6/

Adverse impacts resulting from location in the tsunami flood zone include the risks of destruction of property and loss of life. The proposed action will require development in the inundation zone such as harbor backup facilities. There is no alternative location for these facilities, however, utilizing construction practices which meet requirements of the National Flood Insurance Program will minimize tsunami damages. Adverse impacts resulting from increased use of the tsunami flood zone can be minimized by adequate tsunami warning. A State-wide tsunami warning system is presently in existence. The harbor can be evacuated in the event of a tsunami warning. Boats would not reenter the harbor until the tsunami warning has been cancelled.

HURRICANES. Another infrequent source of large destructive waves is associated with hurricanes. In the last 25 years hurricanes passed through the Hawaiian chain in December 1957, August 1959, July 1978 and most recent November 1982. Theoretical calculations by Dr. C. L. Bretschneifer indicate that a significant deepwater wave height of 27 feet can be expected for a typical 50-year hurricane having the following parameters: (a) central pressure reduction of 1 inch of mercury, (b) radius of maximum winds of 20 nautical miles, (c) forward speed of 12 knots. This results in a maximum sustained wind speed of 62 knots (tropical storm speed) and a corresponding maximum deepwater wave height of 46 feet.

b. REFRACTION ANALYSIS.

Previous wave refraction studies were analyzed for deepwater waves approaching from the North, N.22.5°E., and N.45°E. directions. These directions were selected after evaluating the wave exposure regime for the study area. Deep-water storm waves were analytically transformed considering refraction and shoaling to shallow water wave heights at the entrance to Hilo Bay. Refraction analyses for the various wave approach directions studied indicated that the critical direction for storm waves at Hilo Harbor is north northeast. The computed wave heights for a storm approaching from N.22.5°E were higher than any other direction. Based on a deepwater wave height of 27 feet7/ and a wave period of 17 seconds, the maximum theoretical storm wave height incident to the entrance of Hilo Bay was computed according to SPM equation 2-77:

6/ Cox, D.C. and J. Morgan, 1977 Local Tsunamis and Possible Local Tsunami in Hawaii, HIG-77-14, Hawaii Institute of Geophysics, University of Hawaii, Honolulu.

7/ U.S. Army Engineer District, Honolulu, Corps of Engineers, Technical Report No. 1, 1977.

$$\frac{H}{H_0} = K_R K_S$$

$$H = H_0 K_R K_S$$

where H = wave height in any depth
H_0 = wave height in deep water = 27 feet
K_R = refraction coefficient = 0.81
K_S = shoaling coefficient = 1.30
H = 28.4 feet

c. BREAKING WAVE CONDITION.

Assuming a wave period of 17 seconds to be characteristic of the largest storm wave, seaward bottom to have a slope $m = 0.00$ and $H_b = 28.4$ feet.

Breaker depth (d_b) from SPM figure 7-2 is:

$$\frac{H_b}{gT^2} = \frac{28.4}{32.2(17)^2} = 0.0031$$

$d_b(max) = \quad H_b = 1.5\ (28.4) = 43$ feet

$d_b(min) = \quad H_b = 1.28\ (28.4) = 36$ feet

Breaker travel distance (x_p) from SPM EQ 7-3

$x_p = \quad p\ H_b = [4.0 - 9.25m] H_b = 114$ feet

Based on the foregoing calculations, the design storm wave of 28.4 feet will be fully broken seaward of the 30-foot contour. Thus, the design wave for the harbor structures in the bay must be based on the largest wave generated by either wave forecasting for shallow water or diffraction-refraction analysis performed in accordance with procedures, techniques and diagrams described in the SPM.

6. WAVE CONDITIONS IN HILO BAY

a. FORECASTING FOR SHALLOW WATER WAVES. The wave heights and periods for various wind directions, fetch lengths and average constant depths are tabulated from Coastal Engineer Technical NOTE, CETN-I-6, Mar 1981.

Location of Improvements (Plate D-2)	Wind Direction	Fetch (Feet)	Average[8/] Constant Depth (Feet)	U (MPH)	H_f (Feet)	T_f Second
1	East	4300	20	75	1.9	2
	Southeast	6700	20	75	2.5	2
	South	5200	20	75	2.1	2
	Southwest	5400	20	75	2.2	2
	West	5400	20	75	2.2	2
2	East	5000	20	75	2.0	2
	Southeast	4600	20	75	1.9	2
	South	2500	35	75	1.5	2
	Southwest	6300	30	75	2.5	2
	West	6700	30	75	2.6	2
3	East	1700	15	75	1.3	2
	Southeast	2900	20	75	1.5	2
	South	2100	20	75	1.4	2
	Southwest	7500	30	75	2.5	3
	West	8800	35	75	2.7	3
4	East	800	15	75	0.8	1
	Southeast	1700	20	75	1.3	2
	South	1700	20	75	1.3	2
	Southwest	3300	20	75	1.7	2
	West	8300	30	75	2.8	3
5	West	4200	35	75	1.9	2
	Northwest	10000	35	75	3.0	3
6	North	3300	20	75	1.7	2
	Northeast	2100	25	75	1.4	2
	Northwest	5000	35	75	2.0	3

b. DIFFRACTION-REFRACTION ANALYSIS. The previous theoretical wave diffraction-refraction studies were also analyzed, the incident wave perpendicular to the tip of the existing Hilo breakwater is assumed to be the maximum nonbreaking wave of 16.8 feet based on controlling depth of 21.5 (18 feet plus SWL) feet, m = 0.00. The results of the diffraction-refraction analysis are tabulated in the following Table D-4.

8/ Includes design SWL (3.5 feet).

TABLE D-4. DIFFRACTION - REFRACTION ANALYSIS

Approaching Deepwater Wave Direction	Wave Period (sec)	Azimuth of Approaching Wave 9/ (degrees)	Incident Wave 10/ Height, H_I (feet)	(1) K'	H 11/ (feet)	(2) K'	K_R	K_S	H 12/ (feet)	(3) K'	K_R	K_S	H 12/ (feet)	(4) K'	K_R	K_S	H 12/ (feet)	(5) K'	K_R	K_S	H 12/ (feet)	(6) K'	K_R	K_S	H 12/ (feet)
North	17	139	16.8	0.5	8.4	0.25	0.50	1.21	2.5	0.30	0.55	1.16	3.2	0.30	0.55	1.36	3.8	0.35	0.31	1.16	2.1	0.40	0.31	1.47	3.1
N 22.5°E	17	141	16.8	0.5	8.4	0.25	0.49	1.21	2.5	0.30	0.58	1.16	3.3	0.30	0.58	1.36	4.0	0.35	0.29	1.16	2.0	0.40	0.41	1.47	4.1
N 45°E	17	136	16.8	0.5	8.4	0.25	0.41	1.21	2.1	0.35	0.37	1.16	2.5	0.35	0.37	1.36	3.0	0.35	0.30	1.16	2.0	0.40	0.41	1.47	4.1
North	14	141	16.8	0.6	10.1	0.15	0.53	1.05	1.4	0.18	0.43	1.06	1.4	0.18	0.43	1.24	1.6	0.18	0.21	1.07	0.7	0.25	0.38	1.34	2.1
N 22.5°E	14	152	16.8	0.6	10.1	0.17	0.76	1.05	2.3	0.20	0.45	1.06	1.6	0.20	0.45	1.24	1.9	0.25	0.39	1.07	1.8	0.25	0.39	1.34	2.2
N 45°E	14	139	16.8	0.6	10.1	0.25	0.43	1.05	1.9	0.30	0.51	1.06	2.7	0.30	0.51	1.24	3.2	0.40	0.20	1.07	1.3	0.45	0.38	1.34	3.8
North	10	147	16.8	0.3	5.0	0.20	0.54	0.95	1.7	0.30	0.37	0.97	1.8	1.30	0.37	1.09+	2.0	0.35	0.13	0.96	0.7	0.35	0.23	1.15	1.6
N 22.5°E	10	139	16.8	0.3	5.0	0.20	0.41	0.95	1.3	0.20	0.45	0.97	1.5	0.20	0.45	1.09	1.6	0.25	0.32	0.96	1.3	0.25	0.32	1.15	1.5
N 45°E	10	151	16.8	0.3	5.0	0.12	0.50	0.95	1.0	0.12	0.46	0.97	0.9	0.12	0.46	1.09	1.0	0.13	0.35	0.96	0.7	0.16	0.35	1.15	0.9

9/ Azimuth is measured with south as zero.

10/ Assumed to be a broken and reformed wave of 16.8 feet, based on a controlling depth of 21.5 feet and a slope m = 0.00.

11/ $H = H_I K'$.

12/ $H = H_I K' K_R K_S$.

7. SELECTED DESIGN CONDITIONS

a. ASTRONOMICAL TIDE.

The astronomical tide is estimated to be comparable to the mean higher high water or 2.6 feet.

b. ATMOSPHERIC PRESSURE DROP.

The water level rise due to atmospheric pressure is calculated by,

$$S_p = 1.14\ (P_n - P_o)\ (1 - e^{-R/r}) \quad \text{EQ. 3-85, SPM}$$ 3/

Assuming parameters of hurricane Fico, 1978

P_n = 29.92 inches
P_o = 28.20 inches
R = 25 nautical miles
r = 100 nautical miles

S_p = 0.4 feet

c. STORM SURGE.

The water level rise due to storm surge is calculated by:

Storm surge = S_i, where S_i is the incremental rise in water level due to wind stress perpendicular to the bottom contour

$$S_i = \frac{540K\ U_R\ X}{\bar{d}} \quad \text{(TR-4, 1-64)}$$ 4/

X = total distance in N.M.

$K = 3.0 \times 10^{-6}$

U_R = 62 knots

X = incremental distance in N.M.

d = mean depth over increment (FT)

d_i = initial depth

Storm surge in the study area is estimated to be in the neighborhood of 0.5 feet for the July 1978 hurricane Fico.

3/ U.S. Army Coastal Research Center, Shore Protection Manual, 3rd Edition, 1977.

4/ U.S. Army Coastal Research Center, Technical Report No. 4, 3rd Edition, 1966.

d. DESIGN STILLWATER LEVEL. The design stillwater level (SWL) during hurricane conditions consists of (1) astronomical tide, (2) the rise due to atmospheric pressure drop, and (3) the rise due to storm surge.

(1)	Astronomical Tide	+2.6 ft.
(2)	Atmospheric Pressure Drop	+0.4 ft.
(3)	Storm Surge	+0.5 ft.
	SWL =	+3.5 ft.

e. DESIGN WAVE HEIGHTS. Design wave heights are based on the largest wave generated by either wave forecasting for shallow water or diffraction-refraction analysis. Table D-5 shows the design wave heights and wave periods obtained at areas of improvements in Hilo Bay.

TABLE D-5. DESIGN WAVE HEIGHTS

Area of Improvement (see Plate D-2)	Wave Height, H (feet)	Wave Period (seconds)	Depth of Structure, ds (feet)		
1	10.1	14	18.5	nonbreaking	wave
2	2.6	2	18.5	"	"
3	3.3	15	18.5	"	"
4	4.0	17	15.5	"	"
5	3.0	3	38.5	"	"
6	4.1	14	11.5	"	"

8. PLAN COMPONENTS

a. HARBOR DEEPENING

(1) Entrance Channel.

Minimum Width. Required channel width is based on one-way passage of the design vessel. Total channel width is the sum of (1) bank clearance lane and (2) the maneuvering lane widths all based on the design vessel. Width factors are calculated assuming poor vessel handling qualities, presence of strong and gusty winds, and rough sea conditions. Lane widths and total channel width are:

Lane	Factor x Beam (feet)	Width (feet)
Bank clearance	1.5 x 92	138
Vessel maneuvering lane	1.8 x 92	166
Bank clearance	1.5 x 92	138
TOTAL	4.8 x 92	442

USE: 440 FEET

NOTE: The navigable width is wider than required for one-way traffic. The establishment of a minimum channel width was considered for maintenance dredging.

Minimum Depth. Required depth for safe navigation of the design vessel is computed as the sum of the following items at the calculated and estimated values shown.

Squat. The condition of vessel underway, when the water surface from the quarter point to the stern of the vessel drops below normal level causing the vessel to settle at the stern. In effect, the ship is traveling in a trough between the bow and stern wave, the mean level of which is below the mean level of the surrounding undisturbed free water. Squat increases with an increase in speed and also increases with a decrease in depth of water under the keel. Depth computations for squat are as follows:

Cross-sectional area (see Plate D-2)

design vessel: 3,300 sq. feet
waterway: w_1 = 165,400 sq. feet, perpendicular to area 1
w_2 = 110,100 sq. feet, perpendicular to area 2

Mean depth in the cross-sectional area

waterway: h_1 = 23.6 feet, perpendicular to area 1
h_2 = 29.4 feet, perpendicular to area 2

Using Sogreah Method (EM 1110-2-1607) S 0.080 assume vessel speed
V = 5 knots = 8.4 ft/sec.

Area 1 :

$$S = \frac{A}{h_1 w_1} = \frac{3312}{(23.6)(165,400)} = 0.0008$$

Limiting velocity, $V_L = F(gh_1)^{\frac{1}{2}}$ F = 1.0

$$= 1.0[(32.2)(23.6)]^{\frac{1}{2}}$$
$$= 27.6 \text{ feet/sec}$$

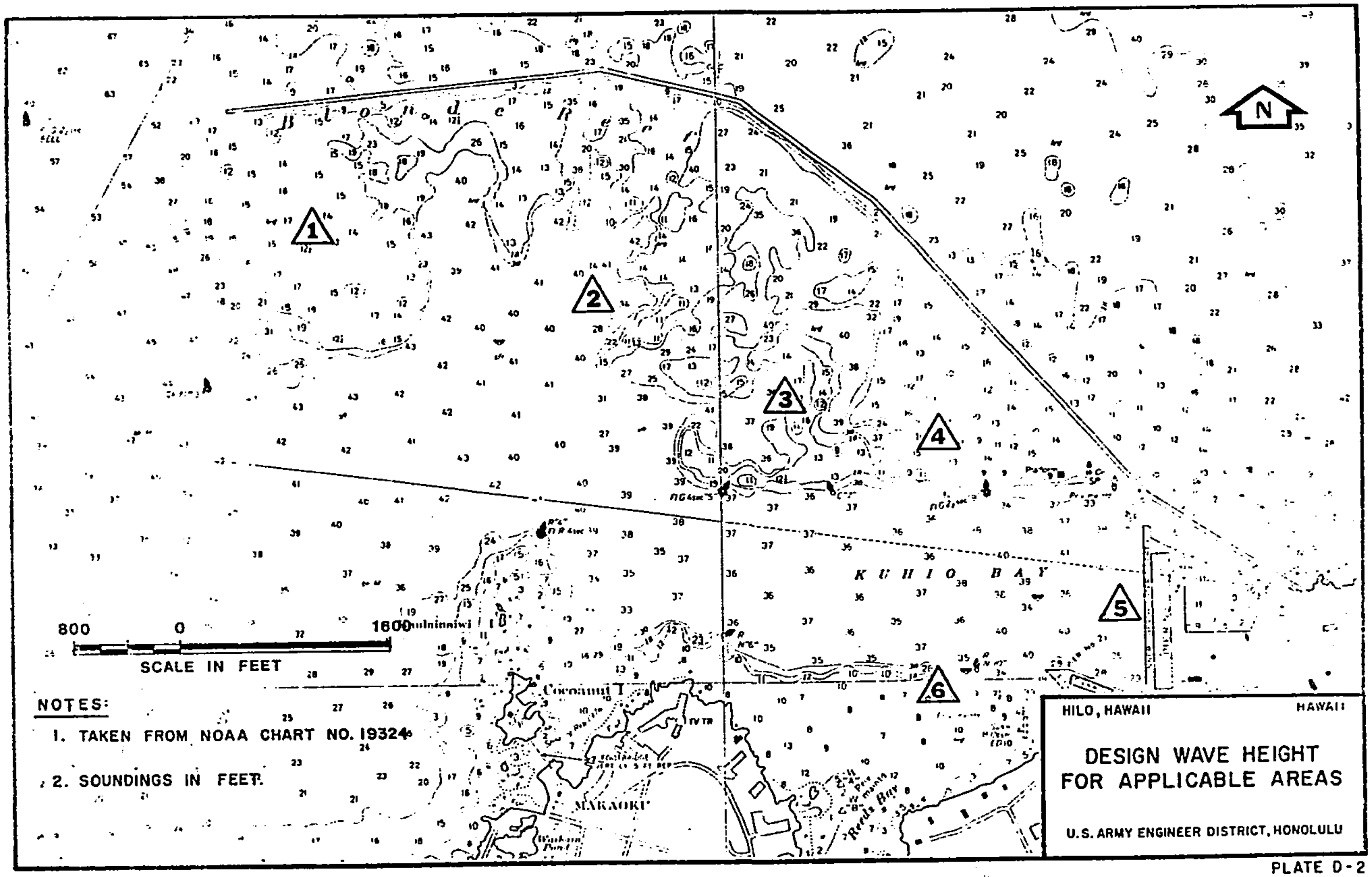

Blonde Reef
KUHIO BAY
Coconut I.
MAKAOKU
1
2
3
4
5
6
N
800 0 1600
SCALE IN FEET
NOTES:
1. TAKEN FROM NOAA CHART NO. 19324
2. SOUNDINGS IN FEET
HILO, HAWAII
HAWAII
DESIGN WAVE HEIGHT
FOR APPLICABLE AREAS
U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE D-2

$$\frac{V}{V_L} = \frac{8.4 \text{ ft/sec}}{27.6 \text{ ft/sec}} = 0.3$$

$$\frac{Z_{max}}{h_1} = 0.01 \qquad Z_{max} = \text{Squat}$$

$$= 0.01\ h_1$$
$$= 0.01\ (23.6 \text{ feet})$$
$$= 0.2 \text{ feet}$$

Area 2 :

$$S = \frac{A}{h_2 w_2} = \frac{3312}{(29.4)(110,100)} = 0.001$$

$$\text{Limiting velocity, } V_L = F(gh_2)^{\frac{1}{2}} \qquad F = 1.0$$
$$= 1.0[(32.2)(29.4)]^{\frac{1}{2}}$$
$$= 30.8 \text{ feet/sec}$$

$$\frac{V}{V_L} = \frac{8.4 \text{ ft/sec}}{30.8 \text{ ft/sec}} = 0.27$$

$$\frac{Z_{max}}{h_2} = 0.008 \qquad Z_{max} = \text{Squat}$$

$$= 0.008\ (29.4 \text{ feet})$$
$$= 0.2 \text{ feet}$$

Use: 0.2 feet

Longitudinal Trim: Draft is increased by cargo imbalance in the lengthwise direction. The magnitude of the trim is estimated at 1.0 feet based on discussion with shippers.

Scend: Sinkage of vessels in waves of relatively long wave length. Its magnitude increases with increase in wave height and with decrease in length of vessel relative to wave length. The magnitude also increases with the increase in ratio of vessel displacement to waterway opening. Since the waterway area is large relative to the vessel displacement area a sinkage factor of 0.5 feet is selected for Hilo Harbor.

Wave Height Allowance: Since the trough of waves below stillwater level is generally 1/3 to 1/2 of the wave height a wave allowance is required for determining navigation depth requirements. For the Hilo Harbor channel it is expected that ships would be traversing the channel in 6-foot waves under severe channel conditions. A 2-foot allowance is selected for wave height allowance. For the basin a 1.5-foot allowance is selected. Based on a wave height in the basin of 4 feet with wave heights outside the breakwater at approximately 15 feet.

Bottom Clearance. Distance from the lowest point on the keel to bottom of waterway. A minimum of 2 feet is needed to avoid damages to ship propellers from sunken timbers or other debris and to minimize displacement of bottom material by ship propellers.

	Channel Depth Rqm't (feet)
Vessel draft	34.0
Squat and trim	1.2
Scend	0.5
Wave height allowance	2.0
Bottom clearance	2.0
Design Depth	39.7
Use:	40.0 feet

(2) Harbor Basin Design.

Minimum Basin Length and Width. A turning basin is provided so that the design vessel can turn around under tug assistance. Based on observation of vessel movement, it has been the practice to provide a basin at the head of, or adjacent to and utilizing, the harbor channel so that the turning diameter is 1.5 to 2.0 times the vessel's length. The variance in diameter will depend on weather conditions and congestion in the area of the turning maneuver. The minimum basin length and width of 1,400 feet to allow for maneuverability of the design vessel were computed as follows:

minimum length and width = 2 x length of design vessel
= 2 x 700'
= 1400'

		Depth (Feet)
minimum depth:	vessel draft	34.0
	squat and trim	1.2
	scend	0.5
	wave height allowance	1.5
	bottom clearance	2.0
	Design depth	39.2
	Use:	39.0 feet

b. BREAKWATERS

(1) Rubble-Mound Breakwaters.

Procedures and formulas contained in the SPM were used to determine the various structure design. The following factors and coefficients are selected based on information available on materials and on the evaluations presented earlier.

The following factors were used in armor layer computations:

	Area of Improvement (See Plate D-2)				
	1	2	3	4	6
Unit weight of armor: W_r (lb/ft^3)			160-162		
Specific gravity of armor stone: S_r			2.6		
Stability coefficient: Head section: K_D	3.2	2.9	2.9	3.2	3.2
Trunk section: K_D	4.0	3.5	3.5	4.0	4.0
Side slope: Cot θ 13/			1.5		
Layer coefficient: K			1.15		
Design wave height: H (feet) 14/	10.1	2.6	3.3	4.0	4.1

Armor stone size:

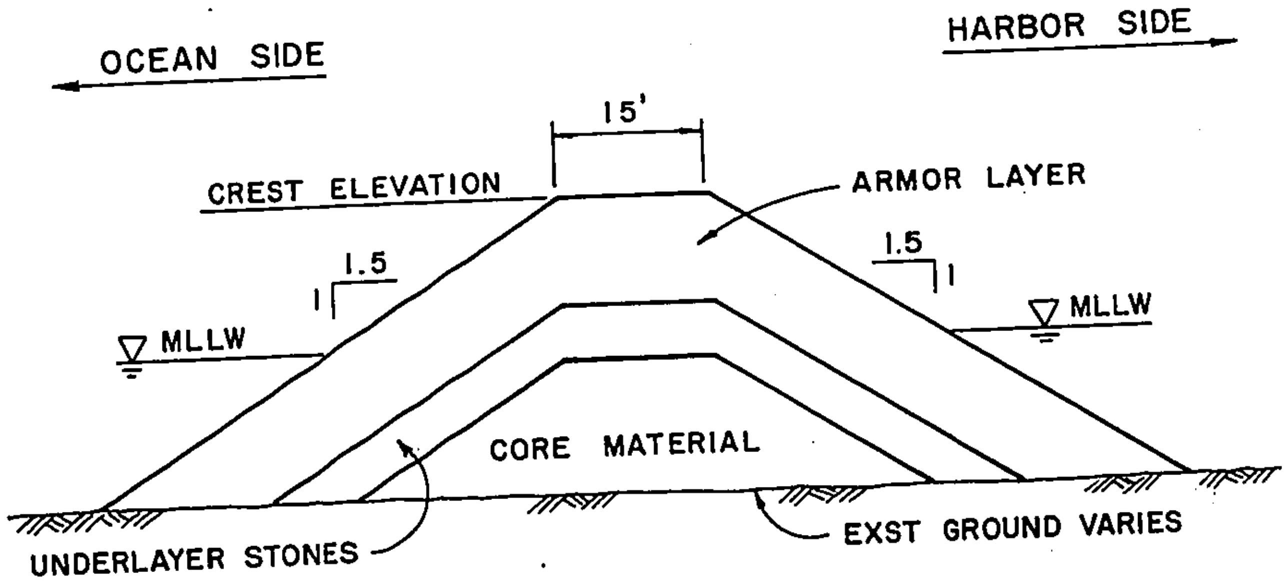
$$W = \frac{W_r H^3}{K_D (S_r - 1)^3 \text{ Cot}} \qquad \text{EQ. 7-11, SPM}$$

Thickness of armor layers and underlayers:

$$r = nK \left(\frac{W}{W_r}\right)^{\frac{1}{3}} \qquad \text{EQ. 7-113, SPM}$$

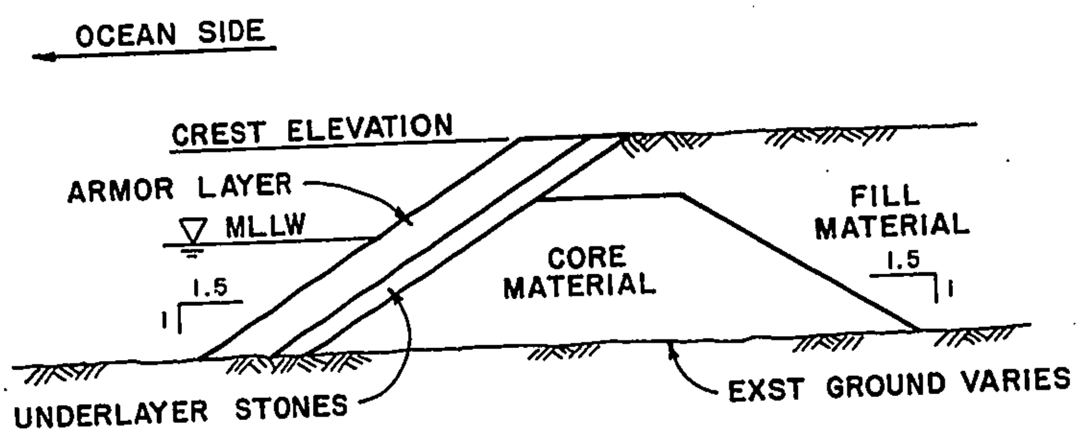
Maximum Runup and Crest Elevation. The runup and resulting crest elevation were based on criteria contained in the SPM and from existing information. 15/, 16/ Assume the maximum runup occurs when the incident waves approach parallel to the structure. The runup diminishes where the incident waves begin to approach at an angle of 90° (angle between the crest and structure). Typical rubble-mound cross section is shown on Plate D-3.

13/ Slope perpendicular to wave front
14/ nonbreaking wave
15/ CETA Report No. 79-1, Wave Runup on Rough Slopes, July 1979.
16/ TP Report No. 78-2, Reanalysis of Wave Runup on Structures and Beaches, March 1978.



TYPICAL STONE BREAKWATER SECTION

NOT TO SCALE



TYPICAL STONE REVETMENT SECTION

NOT TO SCALE

The crest elevation, weight and thickness of the stone layers for the breakwaters are shown on Table D-6. Typical breakwater sections are shown on Plate D-3. Rubble-mound breakwater plan is shown on figure 4 of main report.

TABLE D-6. CREST ELEVATION, STONE WEIGHT AND LAYER THICKNESS FOR RUBBLE-MOUND BREAKWATERS

		Armor Layer		Underlayer		Core Material
Location	Crest Elevation (feet)	Design Stone Weight	Layer Thickness (feet)	Design Stone Weight (pounds)	Layer Thickness (feet)	Design Stone Weight (pounds)
4	+10.0	500 to 1000 lb	3.8	50 to 200	2.0	spalls to 50
6	+10.0	500 to 1000 lb	3.8	50 to 200	2.0	spalls to 50

(2) Floating Breakwater. A floating breakwater is a structure designed to protect an area exposed to short-period, wind-generated waves. These structures are being used in sheltered areas such as inland waterways, lakes and ponds. They are being used for shore erosion control, as combination breakwater and docks for marinas, temporary protection for dredging operation and other protected bodies of water. Floating breakwaters are low profile structures designed to prevent wave energy transmission by reflection and dissipation through interaction with the breakwater structure. They may be constructed in a module arrangement of varying size, shape and components. Floating breakwaters were eliminated from further consideration because no floating breakwater has yet been developed that will economically and sufficiently attenuate ocean waves except for rare occasions (i.e., the formations of a portable harbor for military use), the use of floating breakwaters of any type is not very practical unless the wave environment consists of short period waves (less than seven seconds) and water depths that are deep relative to wave length. In the harbor the breakwater will only "ride" the wave rather than dampen it.

c. SUBMERSIBLE MOORING BUOY

(1) Existing Condition.

The existing mooring buoy at Hilo Harbor consists of two 15,000-pound ship's anchors joined at a common ground ring via two 45' long 3" ground chains. A 60' long, 3" riser chain connects the ground ring to a riser buoy with tension bar. There is a 3-1/2" shackle at the buoy to which ship's lines are secured.

The mooring buoy system is used to secure the berthed ship away from the pier during heavy surge conditions to protect both ship and pier from damage.

At its present location, the buoy presents an obstruction which considerably limits the available maneuvering area in the harbor turning basin.

The proposed submersible buoy was developed as a possible means by which the obstruction posed by the buoy might be removed, while maintaining the present surge anchorage capability at Hilo Harbor.

(2) Description of Proposed Scheme.

The submersible buoy employs (Plates D-4 and D-5) the existing anchor and ground chains to provide anchorage against surge. Anchorage working capacity therefore remains unchanged. All components and fittings which make up the new system are sized to provide at least the capacity of the existing system.

The system consists of a shore compressor and controls, 1,000 LF of rigid pneumatic submarine pipeline, submersible tube-buoy, connecting linkage fittings, anchor sinker weight, and the existing anchor and ground chains.

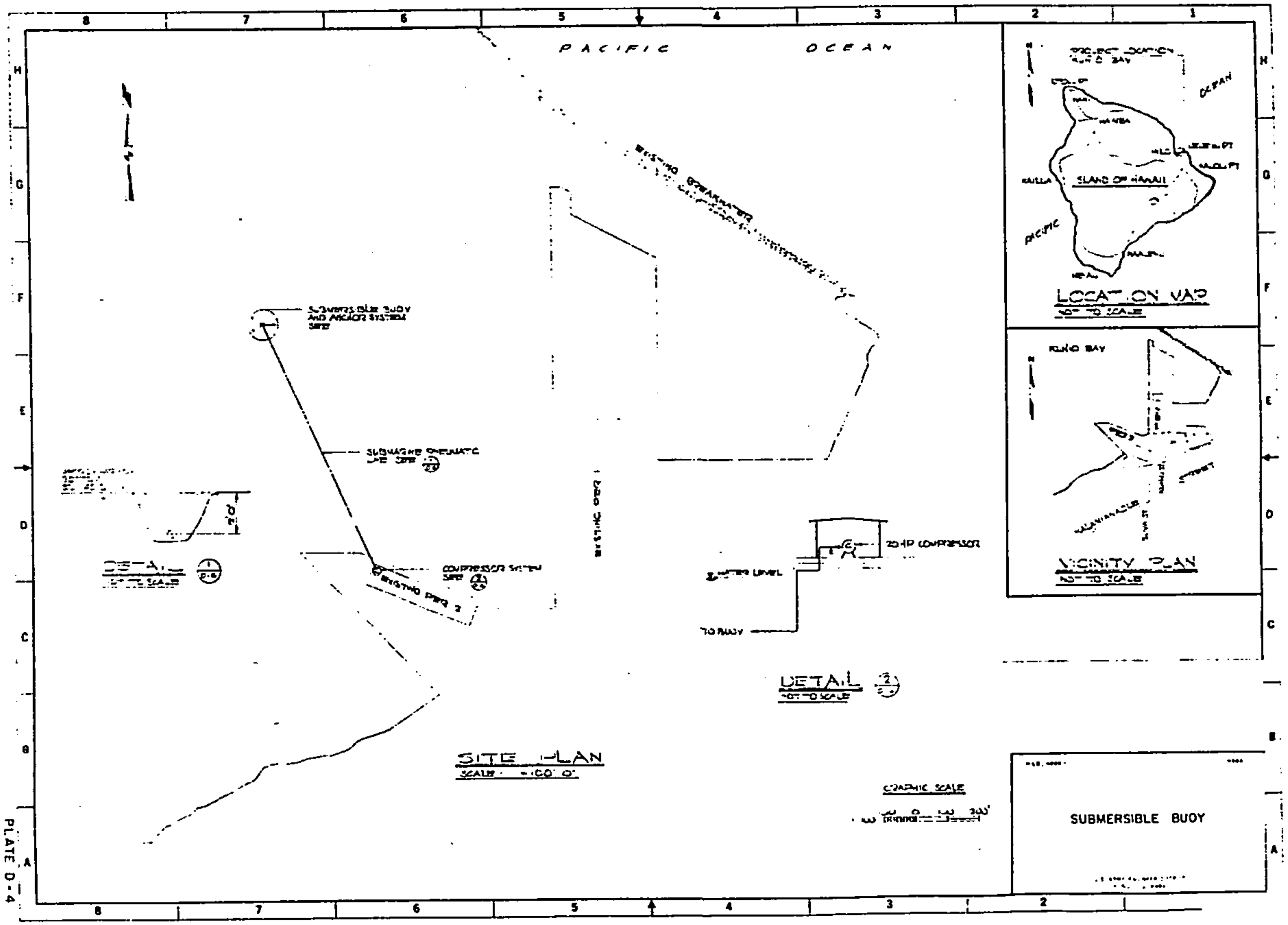
The buoy is an 18" diameter steel tube fitted with a fabric-reinforced rubber air sac which, when inflated, snugly fits the inner space of the buoy tube. The air sac is connected to the compressor via the submarine pneumatic line and valve controls. The pneumatic line terminates with a perforated section of plastic pipe within the air sac to distribute air pressure during inflating and to insure that localized bubbles do not form during flooding of the tube. The tube is perforated at intervals along its entire length, with a rubber valve fitted to each perforation. The valves will pass water in either direction when differential pressures occur. The valves will minimize entry of debris and/or marine life into the inner space of the tube. One end of the tube buoy is attached by a linkage arrangement to the sinker weight and anchor ground chains. The other end is fitted with a shackle to which the using ship's lines can be attached. The tube serves as a tension rod link between the ship's lines, as well as a boom which can be raised, by buoyancy means, to surface the tip to which the ship's lines are attached. The linkage connection between the buoy, sinker weight and ground chains is arranged to permit the buoy two degrees of angular freedom: 45° vertical and about 180° horizontal. The vertical freedom is required for the normal operation of the system. The horizontal freedom is necessary to free the buoy to move (point) in the direction of the thrust of the propellers of a ship operating in the vicinity of the buoy resting on the bottom.

The sinker weight is sized to prevent vertical displacement of the lower and of the buoy during normal use of the anchorage system. This reduces the length requirement of the flexible pneumatic lines at the connection between the buoy and the rigid submarine pneumatic line.

(3) Operation.

When anchorage is required during surge conditions, pressurized air will be introduced into the air sac in the tube-buoy, displacing and thereby expelling water. The tip of the buoy would then surface, enabling ship's lines to be secured to the buoy. The ship can then be held just clear of the wharf, preventing impact damage thereto.

When no longer needed, the ship's lines would be disconnected and the tube laid on the harbor bottom by releasing the air pressure, thereby flooding the tube and collapsing the air sac.



PACIFIC OCEAN
LOCATION MAP
NOT TO SCALE
ISLAND OF HAWAII
VICINITY PLAN
NOT TO SCALE
SITE PLAN
DETAIL
NOT TO SCALE
20 HP COMPRESSOR
TO BUOY
GRAPHIC SCALE
SUBMERSIBLE BUOY

PLATE D-4

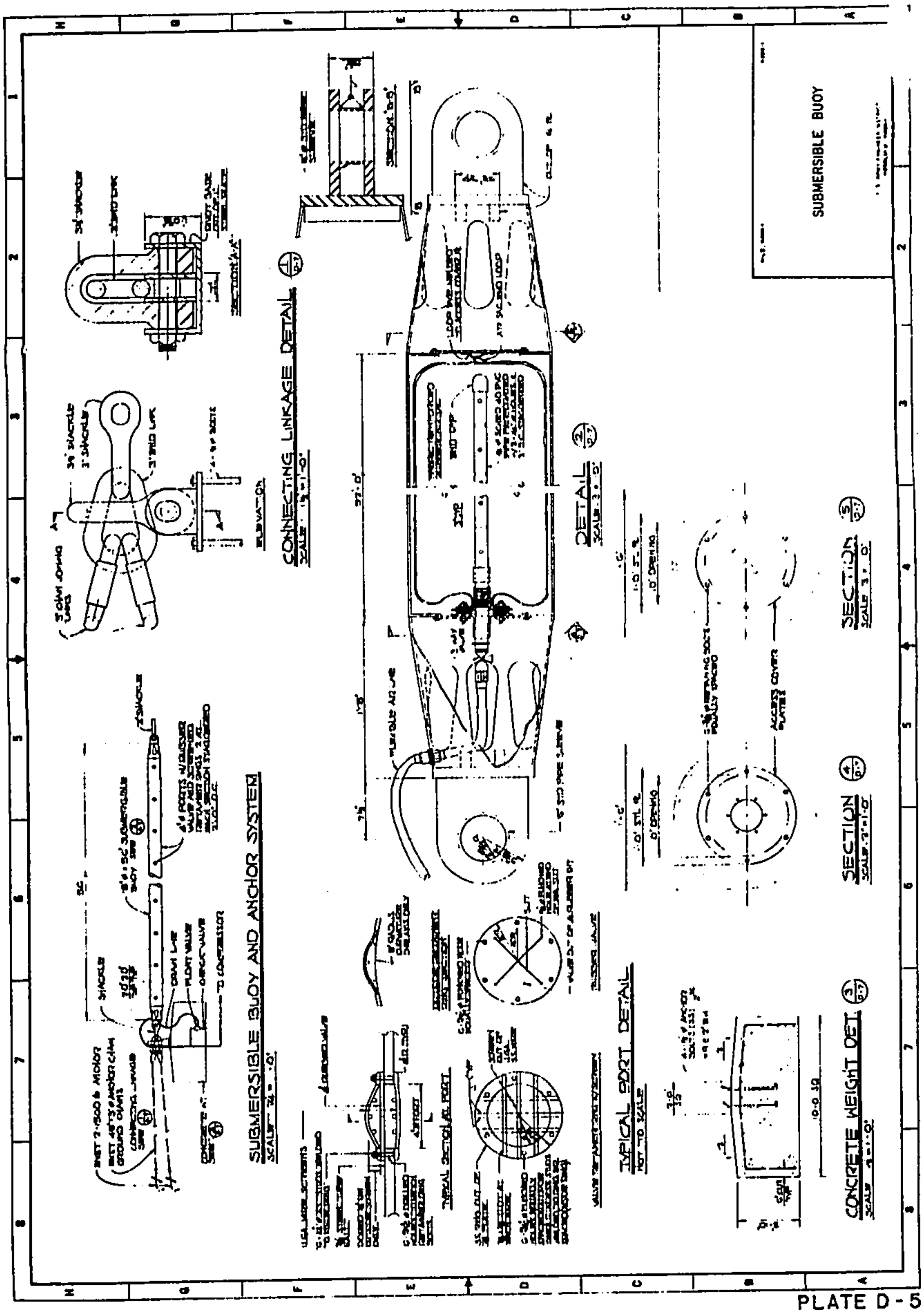

SUBMERSIBLE BUOY
CONNECTING LINKAGE DETAIL
SUBMERSIBLE BUOY AND ANCHOR SYSTEM
DETAIL
SECTION
SECTION
TYPICAL PORT DETAIL
CONCRETE WEIGHT DET.

PLATE D-5

(4) Other Considerations.

To insure proper operation, a model test of the system should be accomplished, and design changes dictated by the results of the test made, prior to construction and installation of the prototype.

If employed, the proposed system operating procedures should include a hazard warning plan such as the use of hazard marker buoys in the vicinity of the rising buoy, in addition to alarm warning or audio devices during activation of the system.

Periodic visual inspection of the submerged portions of the system should be made as well as operational tests. These tests should preferably be made concurrently.

d. CIRCULATION IMPROVEMENT.

In order to improve circulation over Blonde Reef and in Hilo Bay a design analysis was made to evaluate the feasibility of reducing the effectiveness of the outer 2,000-feet of the existing breakwater. This required consideration of a new, shorter breakwater to protect the inner harbor (figure 6 of main report).

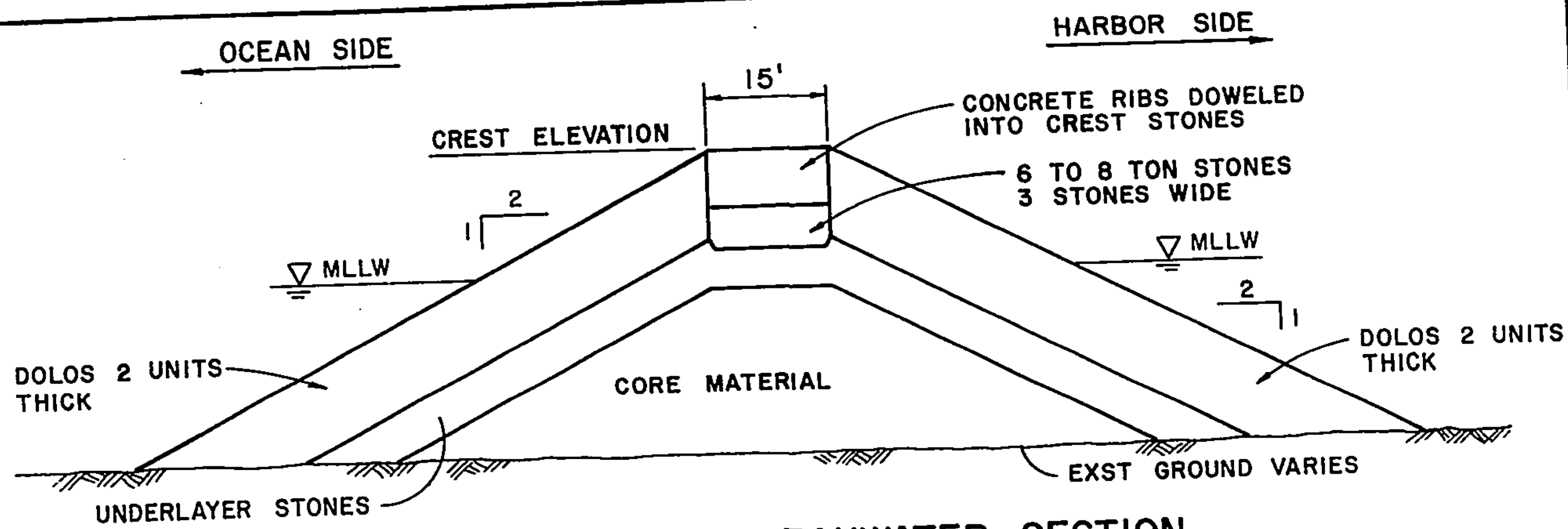
(1) DESIGN WAVE HEIGHT. Calculation of the design wave height was based on the controlling depth criteria. Based on this criteria and the fact that the reef flat fronting the structure has a 0.00 nearshore slope, the design wave height is equal to 0.78 times the depth of water. Using a SWL of 3.5 feet and depth at toe of structure of -14 feet, a controlling depth of 17.5 feet was obtained. The design wave was computed to be 13.7 feet.

(2) DIFFRACTION ANALYSIS. Wave diffraction analyses were analyzed to aid in determining the length of the breakwater and in estimation of wave height reduction in the vicinity of Hilo dock. A wave crest orientation of 90° was selected assuming the existing breakwater seaward of the circulation improvement plan is allowed to deteriorate naturally. Based on the diffraction analysis, the estimated wave height at Hilo docks will be about 10 percent of the incident wave height at the breakwater head.

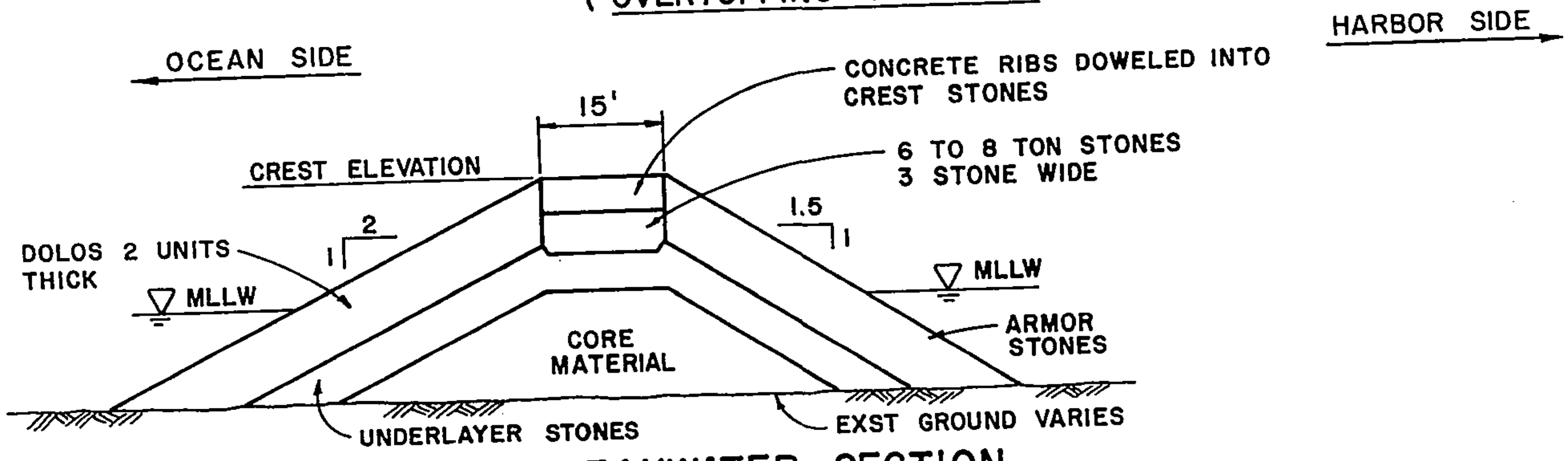
(3) BREAKWATER. The crest elevation, weight and thickness of the dolosses and stone layers for the breakwater are shown on Table D-7. Typical breakwater sections is shown on Plate D-6.

TABLE D-7. CREST ELEVATION, LAYER WEIGHT WEIGHT AND LAYER THICKNESS FOR THE CIRCULATION IMPROVEMENT BREAKWATERS

		Armor Layer		Underlayer		Core Material
Location	Crest Elevation (Feet)	Design Dolosse Weight	Layer Thickness (Feet)	Design Stone Weight (Pounds)	Layer Thickness (Feet)	Design Stone Weight (Pounds)
3	+15.0	4 ton	7.6	600 to 1000	3.9	Spalls to 100



TYPICAL DOLO BREAKWATER SECTION
(OVERTOPPING CONDITION)



TYPICAL DOLO BREAKWATER SECTION
(MINOR OVERTOPPING)

PLATE D-6

e. COMMERCIAL PORT EXPANSION

(1) STRUCTURES. Procedures and formulas contained in the SPM were used to determine the various structure design. The design factors and coefficients are based on information available on materials and on the evaluations presented earlier.

(2) BREAKWATERS. The crest elevation, weight and thickness of layers for the breakwater are shown on Table D-8. Typical breakwater section is shown on Plates D-3 and D-6.

TABLE D-8. CREST ELEVATION, STONE WEIGHT AND LAYER THICKNESS FOR THE COMMERCIAL PORT EXPANSION BREAKWATER

		Armor Layer		Underlayer		Core Material
Location	Crest Elevation (Feet)	Design Stone Weight	Layer Thickness (Feet)	Design Stone Weight (Pounds)	Layer Thickness (Feet)	Design Stone Weight (Pounds)
1	+8.0	4 to 7 ton	9.5	800 to 1400	4.5	spalls to 100
2	+8.5	700 to 1200	4.0	100 to 500	2.8	spalls to 50

(3) REVETTED FILL AREAS. The plan requires construction of a quarry stone revetment to retain dredge material. The revetment would require quarry stones placed on a 1.5 horizontal to 1 vertical slope. This slope is sufficiently flat to adequately dissipate wave energy. In addition, voids between stones would also provide dampening capacity to absorb wave energy, which if reflected back into the harbor could adversely affect navigation. The crest elevation, weight and thickness of the stone layers of the revetted fill area are shown on Table D-9. Typical section of the revetted fill area is shown on Plate D-3. The commercial Port Expansion Plan is shown on figure 5 of main report.

TABLE D-9. CREST ELEVATION, STONE WEIGHT AND LAYER THICKNESS FOR THE COMMERCIAL PORT EXPANSION FILL AREAS

		Armor Layer		Underlayer		Core Material
Location	Crest Elevation (Feet)	Design Stone Weight	Layer Thickness (Feet)	Design Stone Weight (Pounds)	Layer Thickness (Feet)	Design Stone Weight (Pounds)
2 and 3	+8.5	700 to 1200 lb	4.0	100 to 500	2.8	spalls to 50
4	+10.0	500 to 1000 lb	3.8	50 to 200	2.0	spalls to 50

COST ESTIMATE

1. BASIS FOR ESTIMATE

General

a. Estimated quantities were based on existing topograhic and hydrographic maps and surveys and typical plans and section.

b. Estimated construction period and 12% of cost growth are included in the unit cost.

c. Oahu based contractor will do the construction.

d. A 20% contingency cost allowance.

e. All unit prices includes factor for waste.

f. October 1981 price levels.

g. The harbor will operate during construction period.

Dredging

a. Material to be dredged is silt, clay, or broken coral.

b. Dredging by floating clam shell.

c. Ocean disposal of dredged material.

d. All equipment from Oahu except for two dump scows from west const.

e. Minimal blasting required (See Hilo Bay - Bottom Sampling and Jet Probing, pg. 31).

f. 24-hour operation 6 days per week.

g. Estimated construction period is 6 to 8 months.

Breakwaters

a. Armor stones and underlayer stones will be obtained from the Government quarry at Hilo.

b. Equipment working on barge.

c. Estimated construction period is 2-1/2 years.

Submersible Buoy

a. Existing buoy to be removed by others.

b. Cost is for setting anchors, block, buoy, copper pipe (1,000') and placing compressor.

c. Copper pipe laying to be done by floating crane and barge.

d. Copper to be welded in 100 foot lengths on the barge, each length to be lowered into trench from barge and joined under water.

e. Estimated construction period one month.

Circulation Improvement

a. Equipment working on breakwater with steel angle running inside of crane tracks for stability.

b. A 100' x 200' staging area will be built at sta 0+00 of new breakwater. Equipment will be parked in staging area at night.

c. Estimated construction period two years.

Commercial Port Expansion

See dredging and breakwaters above.

2. PLAN COMPONENT FIRST COST

a. HARBOR DEEPENING (Mob and Demob cost included in unit cost)

Item		Quantity	Unit Cost ($)	Total Cost ($)
FEDERAL COST				
Dredge Project Depth	36.0 ft	87,000 CY	11.38	990,000
CONTINGENCY 20%				198,000
TOTAL FEDERAL COST				1,188,000
NON-FEDERAL COST				
Dredge Project Depth	36.0 ft	17,000 CY	11.38	193,000
CONTINGENCY 20%				39.000
TOTAL NON-FEDERAL COST				232,000
TOTAL FIRST COST				1,420,000
FEDERAL COST				
Dredge Project Depth	37.0 ft	162,000 CY	8.49	1,375,000
CONTINGENCY 20%				275,000
TOTAL FEDERAL COST				1,650,000

Item	Quantity	Unit Cost ($)	Total Cost ($)
NON-FEDERAL COST			
Dredge Project Depth 37.0 ft	22,000 CY	8.49	187,000
CONTINGENCY 20%			37,000
TOTAL NON-FEDERAL COST			224,000
TOTAL FIRST COST			1,874,000
FEDERAL COST			
Dredge Project Depth 38.0 ft	255,000 CY	7.25	1,849,000
CONTINGENCY 20%			370,000
TOTAL FEDERAL COST			2,219,000
NON-FEDERAL COST			
Dredge Project Depth 38.0 ft	27,000 CY	7.25	196,000
CONTINGENCY 20%			39,000
TOTAL NON-FEDERAL COST			235,000
TOTAL FIRST COST			2,454,000
FEDERAL COST			
Dredge Project Depth 39.0 ft	349,000 CY	6.64	2,317,000
CONTINGENCY 20%			463,000
TOTAL FEDERAL COST			2,780,000
NON-FEDERAL COST			
Dredge Project Depth 39.0 ft	36,000 CY	6.64	239,000
CONTINGENCY 20%			48,000
TOTAL NON-FEDERAL COST			287,000
TOTAL FIRST COST			3,067,000

Item		Quantity	Unit Cost ($)	Total Cost ($)
FEDERAL COST				
Dredge Project Depth	40.0 ft	485,000 CY	6.23	3,022,000
CONTINGENCY 20%				604,000
TOTAL FEDERAL COST				3,626,000
NON-FEDERAL COST				
Dredge Project Depth	40.0 ft	43,000 CY	6.23	268,000
CONTINGENCY 20%				54,000
TOTAL NON-FEDERAL COST				322,000
TOTAL FIRST COST				3,948,000
b. BREAKWATERS				
FEDERAL COST				
Dredge Project Depth	41.0 ft	611,000 CY	6.00	3,666,000
CONTINGENCY 20%				733,000
TOTAL FEDERAL COST				4,399,000
NON-FEDERAL COST				
Dredge Project Depth	41.0 ft	49,000 CY	6.00	294,000
CONTINGENCY 20%				59,000
TOTAL NON-FEDERAL COST				353,000
TOTAL FIRST COST				4,752,000
FEDERAL COST				
Dredge Project Depth	42.0 ft	760,000 CY	5.83	4,431,000
CONTINGENCY 20%				886,000
TOTAL FEDERAL COST				5,317,000

Item		Quantity	Unit Cost ($)	Total Cost ($)
NON-FEDERAL COST				
Dredge Project Depth	42.0 ft	55,000 CY	5.83	321,000
CONTINGENCY 20%				64,000
TOTAL NON-FEDERAL COST				385,000
TOTAL FIRST COST				5,702,000

b. BREAKWATERS

Item	Quantity	Unit Cost ($)	Subtotal Cost ($)	Total Cost ($)
FEDERAL COST				
Mob & Demob	LS	-	600,000	
Offshore Breakwater				
500-800 lb stones	11,700 CY	94.50	1,105,700	
50-100 lb stones	4,800 CY	66.00	316,800	
Spalls to 20 lb stones	23,500 CY	50.70	1,191,200	
				2,613,700
South Breakwater				
500-800 lb stones	33,700 CY	94.50	3,184,700	
50-100 lb stones	14,400 CY	66.00	950,400	
Spalls to 20 lb stones	112,600 CY	50.70	5,707,700	
				9,842,800
FEDERAL COST (cont)				12,456,500
CONTINGENCY 20%				2,491,500
TOTAL FEDERAL COST				14,948,000
NON-FEDERAL COST				0
TOTAL FIRST COST				14,948,000

c. SUBMERSIBLE MOORING BUOY

Item	Quantity	Unit Cost ($)	Subtotal Cost ($)	Total Cost ($)
FEDERAL COST	Job	-	140,000	140,000
CONTINGENCY 20%				28,000
TOTAL FEDERAL COST				168,000

Item	Quantity	Unit Cost ($)	Subtotal Cost ($)	Total Cost ($)
NON-FEDERAL COST				0
TOTAL FIRST COST				168,000

d. CIRCULATION IMPROVEMENT

Item	Quantity	Unit Cost ($)	Subtotal Cost ($)	Total Cost ($)
FEDERAL COST				
Mob and Demob	LS	-	600,000	
Breakwater				
Develop Quarry	LS	-	265,000	
Workload & Staging Area	LS	-	230,000	
Armor 7-Ton Cap	5,600 CY	70.35	394,000	
4-Ton Dolos	5,500 Ea	315.00	1,734,000	
3-5 Ton Stones	33,400 CY	81.00	2,705,000	
500-1000 lb Stones	24,400 CY	63.00	1,537,000	
1-150 lb Stones	59,300 CY	49.20	2,919,000	
				10,384,000
CONTINGENCY 20%				2,077,000
TOTAL FEDERAL COST				12,461,000
NON-FEDERAL COST				0
TOTAL FIRST COST				12,461,000

e. COMMERCIAL PORT EXPANSION (Entire Plan B)

Item	Quantity	Unit Cost ($)	Subtotal Cost ($)	Total Cost ($)
FEDERAL COST				
Dredging	2,139,300 CY	6.09	13,028,000	13,028,000
Mob and Demob	LS	-		900,000
Stub Breakwater				
500-800 lb stones	33,400 CY	94.50	3,156,000	
50-100 lb stones	15,800 CY	66.00	1,043,000	
Spalls - 20 lb stones	157,400 CY	50.70	7,980,000	12,179,000
North Breakwater				
500-800 lb stones	14,300 CY	94.50	1,351,000	
50-100 lb stones	6,000 CY	66.00	396,000	
Spalls - 20 lb stones	36,100 CY	50.70	1,830,000	3,577,000
South Breakwater				
500-800 lb stones	16,100 CY	94.50	1,521,000	
50-100 lb stones	6,900 CY	66.00	455,000	
Spalls to 20 lb stones	52,200 CY	50.70	2,647,000	4,623,000
				34,307,000
CONTINGENCY 20%				6,860,000
TOTAL FEDERAL COST				41,167,000

Item	Quantity	Unit Cost ($)	Subtotal Cost ($)	Total Cost ($)
NON-FEDERAL COST				
Dredging	311,700 CY	6.09	1,898,000	
Fill Area				
500-800 lb stones	105,400 CY	94.50	9,960,000	
50-100 lb stones	56,200 CY	66.00	3,709,000	
Spalls to 20 lb stones	41,700 CY	50.70	2,114,000	
Dredged Coral Fill	5,142,400 CY	6.50	33,426,000	49,208,000
Access Road				
500-800 lb stones	26,400 CY	94.50	2,495,000	
50-100 lb stones	13,100 CY	66.00	865,000	
Spalls to 20 lb stones	14,900 CY	50.70	755,000	
Dredged Coral Fill	100,100 CY	6.50	650,000	4,765,000
Subbase (Select Material)	6,900 CY	27.50	190,000	
Base Course 4"	1,300 CY	30.10	40,000	
AC Pavement 2"	1,000 T.	45.80	46,000	
Metal Guard Rail	6,200 LF	22.30	138,000	414,000
Remove & Reuse Armor Stone from Existing Breakwater				
8 Ton & Larger	5,800 CY	27.90	162,000	
3 Ton & Larger	1,600 CY	27.90	45,000	207,000
Short Span Bridge	100 LF	3,400.00	340,000	340,000
				56,832,000
CONTINGENCY 20%				11,366,000
TOTAL NON-FEDERAL COST				68,198,000
TOTAL FIRST COST				109,365,000

3. PROJECT FIRST COST. Costs were estimated for October 1981 price levels and updated to October 1982 price levels. Plans A & B include a 20% contingency and Plan C includes a 25% contingency.

a. Plan A (2a + 2b)

Federal Cost		
Dredging *		$3,626,000
Breakwaters		14,948,000
		$18,574,000
Non-Federal Cost		
Dredging *		$322,000
TOTAL PROJECT FIRST COST	(Oct 1981)	$18,896,000
	(Oct 1982)	$20,200,000

b. Plan B (2e) *

Federal Cost		$41,167,000
Non-Federal Cost		$68,198,000
TOTAL PROJECT FIRST COST	(Oct 1981)	$109,365,000
	(Oct 1982)	$116,911,000

c. Plan C.

Item	Quantity(cy)	Unit Cost ($)	Subtotal Cost ($)	Total Cost ($)
FEDERAL COST				
ENTRANCE CHANNEL (-39' mllw)	58,000	7.25	$ 421,000	
TURNING BASIN (-38' mllw)	233,000	7.25	$1,689,000	
CONTINGENCY	25%		527,000	
FEDERAL PROJECT FIRST COST				$2,637,000
NON-FEDERAL COST				
BERTHING AREA (-38' mllw)	27,000	7.25	$ 196,000	
CONTINGENCY	25%		49,000	
STATE PROJECT FIRST COST				$ 245,000
TOTAL PROJECT FIRST COST	(Oct 1981)		$2,882,000	
	(Oct 1982)		$3,081,000	

SUPPORTING DOCUMENTATION

GEOLOGY

HILO HARBOR, HAWAII

HILO BAY - BOTTOM SAMPLING AND JET PROBING

INTRODUCTION

Bottom and sub-bottom investigations were conducted in portions of Hilo Bay for M & E Pacific, Inc. in connection with the overall Hilo Bay study being undertaken by that company for the U. S. Army Corps of Engineers, Pacific Ocean Division. Field work was carried out during the week of March 17-22, 1980. The weather during this period was characterized by strong trade winds,. 15-30 MPH, extremely heavy rainfall causing flash flooding in Hilo, and large ocean swells from the northeast resulting in breaker heights of 10 to 12 feet in the Alealea Point area. The ground water runoff created very turbid waters in the bay severly hampering underwater visibility.

The field study had two major objectives which corresponded with the two different areas of the bay investigated: There were investigations conducted in Hilo Harbor which sought to determine the nature and quality of the bottom for the purpose of estimating the cost and feasibility of planned dredging and construction here; and those conducted outside of the harbor at the north end of Hilo Bay in the vicinity of Alealea Point which sought to better define the quality and extent of a submarine black sand deposit (principally its northward and seaward limits) which was discovered in an earlier study: Hilo Bay Sand Survey, Dec. 1979 prepared for the U. S. Army Engineer District Pacific Ocean by Ocean Innovators, Contract No. DACW84-80-M-0070.

The area of interest within the harbor is broken into sub areas to roughly correspond with various alteration schemes proposed. These are identified as Areas A, B, and C in the Scope of Work for Geological, Biological and Water Quality Investigations Hilo Bay, Hawaii dated 7 December 1979. The area of interest in north Hilo Bay is designated as Area D.

Field investigations consisted of water jet probes and taking of surface and wash samples. Jet probing was accomplished at 61 stations and 33 samples were taken at 27 of these stations. All samples were tagged and delivered to the M & E Pacific Lab on March 26, 1980 for analysis.

METHODOLOGY

STATION SELECTION AND POSITIONING

Six, roughly parallel, transects were traversed in Hilo Harbor in a north-south direction and spaced about 500 feet apart. Each transect crosses through Areas A, B and C and are numbered transects #4 and #9. Probing and sampling stations were located on the transects also about 500 feet apart but this varied to concentrate stations as conditions dictated. Two taut moored buoys were set at the south end of each transect to establish a range line for the boat operator to follow. Station positions along each transect were located by horizontal sextant angles on prominent landmarks. This arrangement of stations on six transects provided a fairly evenly spaced grid for data collection in Areas B and C and the eastern section of Area A. These stations were assigned a hyphenated number corresponding to the transect number and the successive station along that transect; i.e., station number 6-4 refers to the fourth station along transect #6 starting from the south. Additional stations were established to cover the outer reaches of Area A and to collect additional data as was deemed necessary after seeing the results of the transect probes. These stations were simply designated numbers 10 through 20 without reference to a transect number. All stations are shown on Plate 1 .

For the North Hilo Bay sand deposit investigations two transects were layed out running on headings of 090°T and 045°T from the stack at Alealea Point. These were designated transects #1 and #2 respectively. With the results of the jet probes and samples from stations on these transects, transect #3 was set down running 000°T from the lower end of transect #2. The stations along these transects were numbered in a fashion similar to those inside Hilo Harbor. Positions were established as before. All stations are shown on Plate 2 .

JET PROBING AND SAMPLING

A 25 foot boat with operator was chartered for the harbor and offshore work. Jet probing was accomplished using a 2" pump and up to 100' of 2" hose attached to a 10' length of 1" pipe. A diver jetted the pipe vertically into the bottom until some type of refusal was encountered. The refusal was classified as either "hard" indicating a solid bottom layer was reached,

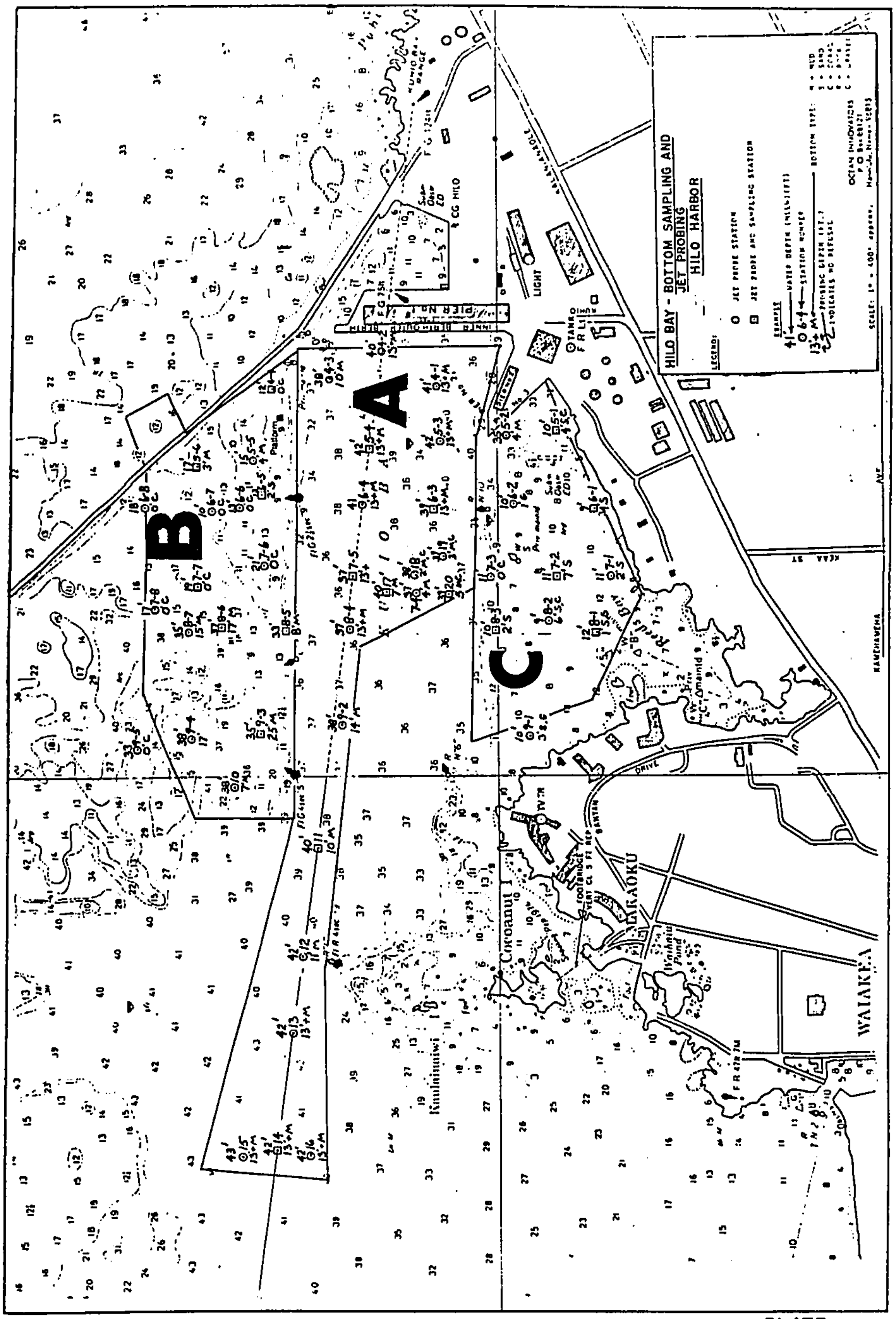
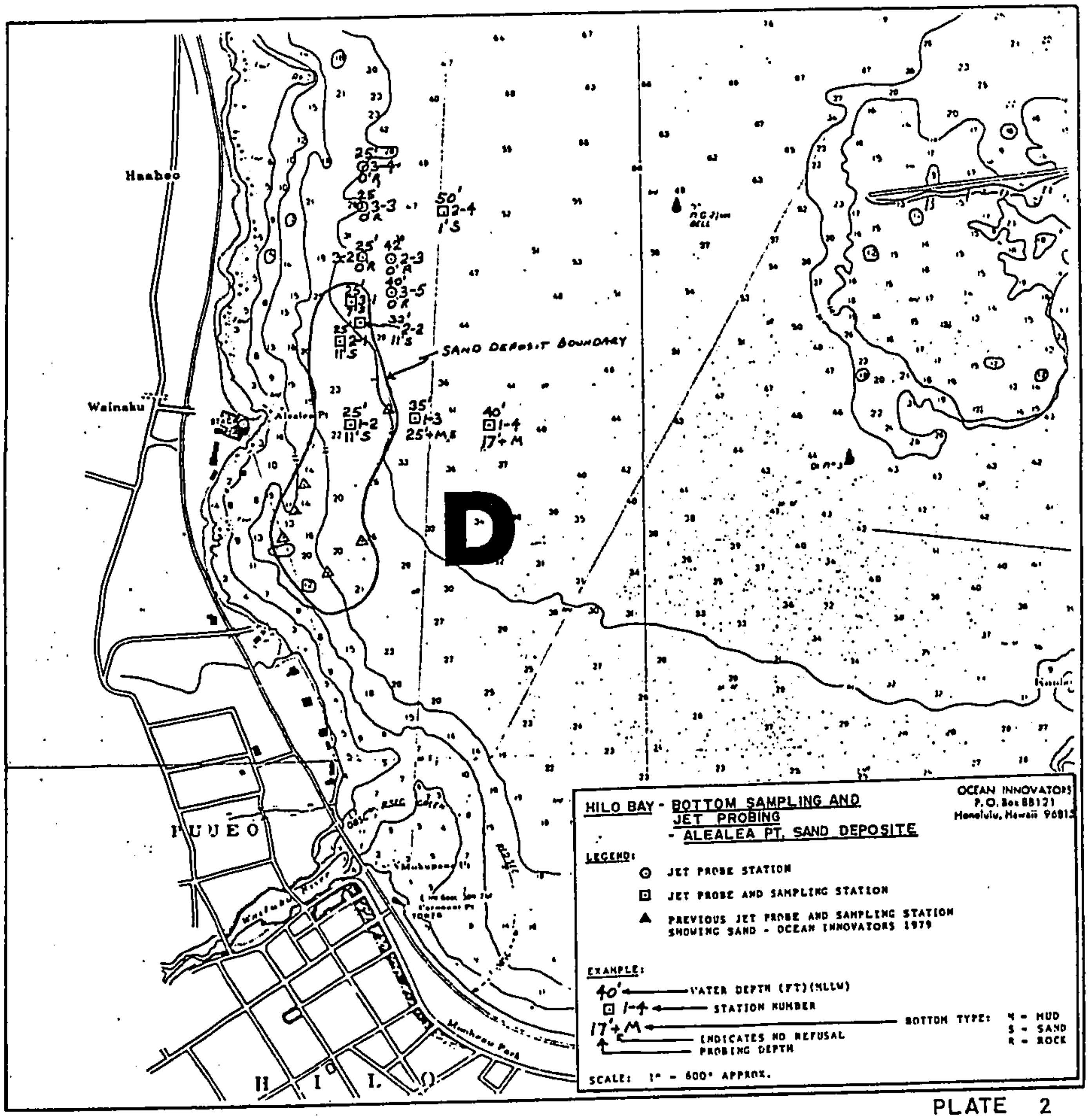

HILO BAY - BOTTOM SAMPLING AND JET PROBING
HILO HARBOR
A
B
C
LIGHT
WAIAKEA

PLATE 1



HILO BAY - BOTTOM SAMPLING AND JET PROBING - ALEALEA PT. SAND DEPOSITE
OCEAN INNOVATORS
P.O. Box 88121
Honolulu, Hawaii 96815
LEGEND:
JET PROBE STATION
JET PROBE AND SAMPLING STATION
PREVIOUS JET PROBE AND SAMPLING STATION SHOWING SAND - OCEAN INNOVATORS 1979
EXAMPLE:
40'
WATER DEPTH (FT)(MLLW)
1-4
STATION NUMBER
17'+M
BOTTOM TYPE:
M - MUD
S - SAND
R - ROCK
INDICATES NO REFUSAL
PROBING DEPTH
SCALE: 1" - 600' APPROX.
SAND DEPOSIT BOUNDARY
D
Haaheo
Wainaku
Alealea Pt
PUUEO
HILO

PLATE 2

"crunchy" indicating gravel or shells were encountered limiting further penetration, or "seizing" generally caused by a collapse of the side walls of the probe hole resulting in a halt to penetration. In some instances this latter type of resistence is confused with a lack of sufficient hose to penetrate further often caused by the boat drifting off position. In either instance the seizing type of refusal leaves open the possibility that the sediment is thicker than the amount shown.

At stations selected for sampling, a surface sample was obtained before jetting began by the diver in a one quart plastic bag. In some instances a "wash" sample was taken from around the perimeter of the probe hole after the probe was extracted to obtain a composite sample of the subsurface sediments. In general wash samples were not taken where mud was encountered throughout the probing range. Since the subsurface mud is washed up and away from the probe hole in suspension, it does not settle out around the hole; thus wash samples are meaningless under these sediment conditions. In some rubble, the wash sample was taken by the diver by reaching to the bottom of the probe hole - see sample 5-6-W. Samples are designated by their station number with the suffix S or W to denote surface or wash sample.

The Scope of Work require jet probes be taken to a minimum depth of 10 feet where sufficient sediment existed. In Area A the diver was instructed to probe to a maximum depth of 13 feet below the bottom where possible and not to attempt to reach refusal beyond this depth. Since Area A, the existing dredged area, may be deepened to -40' MLLW or by less than 10 feet below existing conditions in all cases, there was no point in probing further than 13 feet. In the three remaining areas the diver was instructed to probe to a maximum of 25 feet or until refusal was encountered whichever came first.

Water depths were measured at each station using a lead line and the readings were corrected to MLLW using tide charts. Soundings taken in Area D are not considered reliable due to the large waves which made accurate readings by lead line impossible. Variations of + or - 5 feet are possible. Water depths taken inside Hilo Harbor could likely be a foot or more higher than normal due to fresh water buildup caused by heavy flooding and to possible storm wave setup in the harbor.

Table 1 shows the particle sizes of sediments at various locations in Hilo Bay. Plate 3 shows the locations. The samples were collected from the surface of the upper sediment layer.

RESULTS AND CONCLUSIONS

All jet probing and sampling stations are shown on the charts attached as Plates 1 and 2 Tables 2 and 3 list each jet probing station showing the area in which the station is located, depth of water, type of refusal, comments regarding the probings and samples, and notations of where samples were acquired. Results and conclusions are best stated according to area:

Area A. The majority of stations in this area revealed that the bottom consists mainly of mud (sediments in the silt to clay range) in thicknesses greater than 13 feet. Along the centerline of the channel and in the outer reaches of Area A, refusal at 13 feet or less was encountered twice, at station 11 and station 12, at 10 feet and 11 feet below the bottom respectively. The only station on the transects showing relatively thin sediment in Area A was at station 7-4. Here only 4 feet of mud was found to exist over a probable coral gravel bottom. Several additional probes were later completed in the vicinity of station 7-4, stations 17 thru 20, all showing 3 to 7 feet of mud overlying a crunchy but solid bottom. Since the depth of water at these stations was measured at not less than 37 feet below MLLW, there at first appears to be sufficient sediment to allow dredging to -40 feet by suction dredge. However, the existence of coral heads or rocks protruding through the sediments as observed at station 7-4 and notation of scattered coral formations at stations 17 thru 20 gives some cause for concern that the -40 feet depth can actually be achieved here by suction dredge alone. Furthermore, if a deeper project depth is being considered for the turning basin, then a cutterhead dredge or other means would probably be required in this section of Area A.

Stations 4-3 and 8-5 along the very north edge of Area A showed sediment thicknesses of 10 feet and 8 feet respectively. These would be the bare minimum thicknesses needed to deepen this portion of the turning basin to -40 feet by suction dredge where water depths of 32 to 34 feet are shown to exist on the chart.

TABLE 1

HILO BAY SEDIMENTS SIZE DISTRIBUTIONS
(Percent by Weight)

Station	Size (mm) >4.00	2.00-4.00	1.00-2.00	0.500-1.00	0.250-0.500	1.25-0.25	0.063-0.012	<0.063
Inner Harbor								
A-1-S	29.8	17.4	14.5	11.2	7.1	5.5	3.6	10.9
A-2-S	0.3	0.4	0.7	1.4	2.1	7.9	10.1	77.2
A-3-S	-	0.1	0.2	0.6	0.6	10.0	6.2	82.3
A-4-S	0.1	0.1	0.3	1.1	1.4	16.6	74.0	6.4
A-5-S	0.2	0.3	0.5	0.8	1.9	5.7	6.4	84.3
A-6-S	0.1	0.1	0.2	0.3	2.5	14.3	11.6	70.9
A-7	8.1	13.2	14.9	10.2	3.4	5.1	17.8	27.3
A-8-S	-	0.1	0.2	3.8	3.0	5.2	6.2	81.5
A-9-S	19.8	19.1	16.7	12.8	7.3	5.3	3.2	15.8
A-10-S	50.9	12.3	17.0	13.2	2.5	1.5	0.8	1.8
A-12-S	12.3	4.8	3.5	2.9	3.5	11.0	14.8	47.3
A-13-W	0.1	0.1	2.7	3.8	2.5	4.8	3.9	82.0
A-16-S	7.2	3.8	5.0	4.1	2.3	4.0	4.7	69.0
Outer Harbor								
B-2-S	0.1	0.1	0.1	0.2	0.5	14.3	43.1	41.8
B-3-S	0.2	0.4	0.6	1.4	4.0	16.0	36.0	41.4
B-4-S	0.2	0.4	6.8	20.5	20.7	17.7	15.0	18.6
B-5-S	0.1	0.1	13.0	29.1	26.8	26.8	0.6	3.6
B-6-S	1.1	2.5	7.5	33.6	47.6	6.9	0.3	0.5
B-8	0.3	0.8	3.1	3.4	3.9	7.0	8.9	72.6

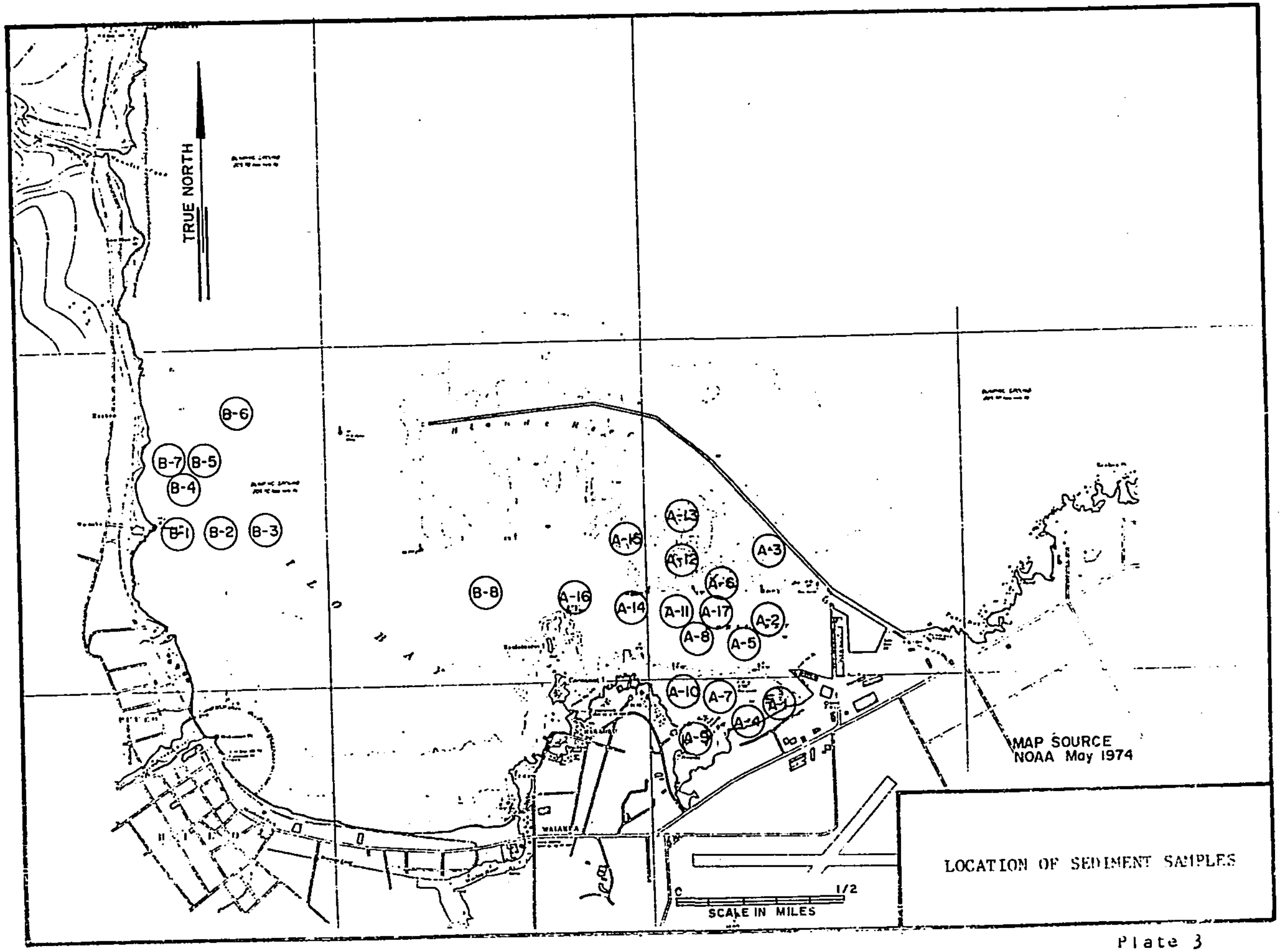

TRUE NORTH
B-1
B-2
B-3
B-4
B-5
B-6
B-7
B-8
A-2
A-3
A-4
A-5
A-6
A-7
A-8
A-9
A-10
A-11
A-12
A-13
A-14
A-15
A-16
A-17
MAP SOURCE
NOAA May 1974
SCALE IN MILES
0
1/2
LOCATION OF SEDIMENT SAMPLES

Plate 3

TABLE 2 JET PROBING LOG - ALEALEA POINT, HILO BAY

STATION NUMBER	AREA	WATER DEPTH (FEET)	PROBING DEPTH (FEET)	TYPE OF REFUSAL	COMMENTS	SAMPLE NUMBER
1-2	D	25	18	Hard	Medium to fine black sand	1-2-S, 1-2-W
1-3	D	35	25	None	Very fine black sand and mud	1-3-S
1-4	D	40	17	None	Black mud	1-4-S
2-1	D	25	11	Hard	Medium black sand and mud layered	2-1-S, 2-1-W
2-2	D	32	11	Hard	Medium to fine black sand	2-2-S, 2-2-W
2-3	D	42	0	Hard	Basalt rock	None
2-4	D	50	1	Hard	Coarse black sand with some calcareous content	2-4-S
3-1	D	25	7	Hard	Coarse to medium black sand	3-1-S, 3-1-W
3-2	D	25	0	Hard	Basalt rock	None
3-3	D	25	0	Hard	Basalt rock	None
3-4	D	25	0	Hard	Basalt rock	None
3-5	D	40	0	Hard	Basalt rock	None

TABLE 3 JET PROBING LOG - HILO HARBOR

STATION NUMBER	AREA	WATER DEPTH (FEET)	PROBING DEPTH (FEET)	TYPE OF REFUSAL	COMMENTS	SAMPLE NUMBER
4-1	A	41	13	None	Slight crunchy layer at 10 feet	None
4-2	A	40	13	Seizing	Close to wharf	None
4-3	A	38	10	Crunchy	Crunchy layer at 7', coral fragments in wash	None
4-4	B	12	0	Hard	Scattered coral rubble, lava boulders, some sand	4-4-S
5-1	C	10	4	Hard	Surface is 50% lava cobbles, 50% sand and gravel	5-1-S
5-2	C	35	4	Crunchy	2 probes	None
5-3	A	43	13	None	Black mud	None
5-4	A	42	13	None	Black mud, composit sample from first 3 feet	5-4-C
5-5	B	15	4	Crunchy	Mud overlying coral rubble	None
5-6	B	17	3	Crunchy	Mud overlying coral rubble	5-6-S, 5-6-W wash from 4' down
6-1	C	9	4	Crunchy	Fine white sand	6-1-S
6-2	C	10	1.5	Crunchy	Coral gravel over rubble, 3 probes	None
6-3	A	39	13	None	Brown/black mud	6-3-S
6-4	A	41	13	None	Mud	None
6-5	B	12	2	Crunchy	Fine sand overlying coral rubble Some coral heads on surface	6-5-S
6-6	B	13	0	Hard	Coral reef	6-6-S
6-7	B	10	0	Hard	Dead coral and coral rubble	None
6-8	B	18	0	Hard	Coral rubble, live coral heads	6-8-S
7-1	C	11	2	Hard	White sand	None
7-2	C	11	7	Hard	Fine brown sand	7-2-S
7-3	C	11	0	Hard	Coral rubble	None
7-4	A	37	4	Crunchy	Mud with coral head or rock protruding	None
7-5	A	37	13	None	Brown/black mud	7-5-S
7-6	B	21	0	Hard	Coral heads on coral rubble	None
7-7	B	19	0	Hard	Live coral, abundant	7-7-S
7-8	B	17	0	Hard	Live coral on coral rubble	None
8-1	C	12	1	Hard	Sand, gravel	8-1-S
8-2	C	9	6	Hard	Coral rubble over sand and gravel	None
8-3	C	9	2	Hard	Sand, gravel	8-3-S
8-4	A	37	13	None	Mud	None
8-5	B	33	8	Hard	Mud, probe 10' from coral reef	8-5-S
8-6	B	37	17	Seizing	Mud	8-6-S, 8-6-W
8-7	B	35	15	Seizing	Mud	None

TABLE 3 JET PROBING LOG - HILO HARBOR (Cont)

STATION NUMBER	AREA	WATER DEPTH (FEET)	PROBING DEPTH (FEET)	TYPE OF REFUSAL	COMMENTS	SAMPLE NUMBER
9-1	C	10	3	Crunchy	Sand and gravel over rubble	None
9-2	A	38	14	Hard	Mud	None
9-3	B	35	25	Crunchy	Brown mud	9-3-W
9-4	B	38	17	Hard	Mud	None
9-5	B	33	0	Hard	Very thin layer of silt over coral reef	None
10	B	38	7	Crunchy	Rocks protruding from rocks	None
11	A	40	10	Hard	Brown Mud	11-S
12	A	42	11	Hard	Mud	None
13	A	42	13	None	Mud	None
14	A	42	13	None	Black Mud	14-S
15	A	43	13	None	Mud	None
16	A	42	13	None	Mud	None
17	A	40	7	Crunchy	2 feet of mud over gravel	17-W
18	A	38	3	Crunchy	Mud with scattered coral formations on surface	None
19	A	13	3	Crunchy	Same as above	None
20	A	39	5	Crunchy	Same as above	

Area B. This area is essentially the southeast portion of Blonde Reef inside the breakwater. The new proposed turning basin will extend into the southeast portion, and a proposed small boat entrance channel, project depth of -15 feet, will cut across the northern half. Stations 4-4, 5-5, 6-5, 6-6, and 7-6 are located within the planned turning basin. They show this area to be coral reef covered partially by thin sediment (2 to 4 feet) over a gravel or coral rubble bottom. The reef flat is exposed in some portions and is covered by scattered lava boulders, live coral heads and coral rubble. Water depths measured at these stations varied from 12 to 15 ft., but these readings may be high due to reasons mentioned. Dredging this area for a turning basin apparently will require a cutterhead dredge or blasting to achieve the -40 feet design depth.

Stations 5-6, 6-8, 7-7, 7-8, 8-7, 9-4, and 9-5 are located in or near the route of a proposed small boat channel. This portion of Area B is composed of shallow reef flats made up of live and dead coral heads and coral rubble and two deep channels that weave through the reef which are covered with a rather thick sediment layer. The depths of water at these stations varies from 10 feet to 35 feet. Only a small portion of the planned channel route would be in water depths of less than 15 feet, yet dredging in this area would be through coral reef and require a cutterhead dredge. A solid coral foundation for breakwater construction seems to exist for most of the breakwater path except in way of the deep channel where up to 17 feet of mud occurs.

Area C. This zone includes the area west of Pier 2 adjacent to Bakers Beach and outside of Reeds Bay at the south end of the harbor. The planned location of the turning basin in two designs for a small boat harbor in this area fall in the zone where maximum sediment thickness occurs, see stations 7-2 and 8-2. The design depth of -12 feet can probably be achieved here by suction dredge or clamshell without difficulty. Conversely, to obtain the project channel depth of -15 feet for either design a cutterhead dredge appears necessary since little or no sediment exists along each of those planned routes, and water depths now are not sufficient. The hard or crunchy substrate generally encountered in this area should provide a good foundation for the breakwaters and revetments as shown in both plans, however borings should be made.

Area D. The offshore sand survey was made difficult by heavy rain showers and large breakers striking Alealea Point and the coastline to the north. It was hazardous if not impossible to obtain data in this area inside the 25 foot contour especially with strong onshore winds. This survey showed little or no usable sand existing seaward of the boundary of the sand deposit as defined in the 1979 Ocean Innovators report. The sediments existing offshore of the 30 foot contour, although thick, become mud mixed with fine sand at the 35 feet level and pure mud at 40 feet. The transects north from Alealea Point showed that the deposit stretches for about 1200 feet north of the point with sand thicknessess diminishing from 11 to 7 feet before running out. A revised sketch of the estimated boundaries of the sand deposit is shown on Plate D-8. Since no data points could be collected inshore of the 25 foot contour, the inner boundary of the deposit is not certain. No further points could be acquired in the southern portion of the deposit due to wave action. Based on this new outline of the deposit it is estimated that about 775,000 cubic yards of black sand exists in this area which has a quality which appears suitable for beach replenishment purposes. However, only a very small portion of this exists in water depths of 30 feet or more and beyond 1000 feet from shore, thus making its recovery questionable from a legal standpoint. The wave action experienced while sampling this area suggests that this deposit would be very difficult to mine at least during certain times of the year.

SUMMARY

1. A layer of soft mud exists on the bottom in Area A sufficiently thick to permit dredging of the channel and existing turning basin to the project depth of -40 feet with a suction dredge. The only areas of slight concern would be in the vicinity of stations 7-4 and 17 through 20 and possibly along the north edge of the existing turning basin where a relatively solid bottom seems to exist at just about the -40 feet elevation.

2. Extending the turning basin up into Area B will undoubtedly require a cutterhead dredge of blasting as will similarly be required for a portion of the small boat channel in this area. The bottom, where exposed, appears to be coral reef or at least has a coral cover layer. The deep channels weaving through the reef have up to 25 feet of mud overlying a hard or crunchy bottom.

3. Area C has up to 7 feet of sand, silt and gravel covering an apparent coral reef. The small boat turning basin can probably be dredged by suction dredge or clamshell. The entrance channels will require a cutterhead.

4. It appears as though there is a satisfactory substrata for breakwater and revetment construction in Areas B and C, however, borings must be conducted before plans and specifications can proceed.

5. The black sand deposit off Alealea Point was found to extend about 1200 feet northward from the point in a narrow band. Offshore of the 30 foot contour the sediment turned to mud where sediment existed. An estimated 775,000 cubic yards of usable quality beach sand exists in this deposit, but recovery may prove difficult due to legal restrictions and strong wave action in this area.

SUPPORTING DOCUMENTATION

ECONOMICS

HILO HARBOR, HAWAII

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858

HILO HARBOR, HAWAII

A SURVEY REPORT AND FINAL ENVIRONMENTAL IMPACT STATEMENT

FOR

DEEP-DRAFT NAVIGATION IMPROVEMENTS

APPENDIX H

ECONOMICS

APRIL 1983

PACIFIC OCEAN DIVISION

APPENDIX H

HILO HARBOR, HAWAII
DEEP DRAFT NAVIGATION IMPROVEMENTS

ECONOMICS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (CONT)

LIST OF FIGURES

APPENDIX H

HILO HARBOR, HAWAII
DEEP-DRAFT NAVIGATION IMPROVEMENTS

ECONOMICS

GENERAL

Existing Federal Project

The existing deep-draft harbor at Hilo is an authorized project which includes a rubblemound breakwater 10,080 feet long; an entrance channel 35 feet deep; and a turning basin 1,400 feet wide, 2,300 feet long, and 35 feet deep. The project was authorized in the River and Harbor Acts of 2 March 1907, 25 July 1912, and 3 March 1925. The project was completed in July 1930.

Problems and Needs

Hilo is the primary commercial port of Hawaii County, an island of more than 4,000 square miles and 92,000 people. Most of the island's general cargo and petroleum inshipments and sugar and molasses outshipments pass through Hilo. The cargo volumes at the commercial port average over a million tons annually. The existing Federal project depth of 35 feet at the entrance channel and turning basin requires an underkeel clearance of 4.8 feet which leaves a vessel operating draft of 30.2 feet. Two bulk sugar vessels that routinely sail from Hilo Harbor to the West Coast have operating drafts greater than 30.2 feet. In addition, a new Integrated Tug and Barge (ITB) will be hauling sugar between Hawaii and the refinery in California in the very near future (November 1982). The ITB has an operating draft of 34 feet when loaded with raw sugar. Thus, to meet immediate and future needs of Hilo and Hawaii a 38-foot deep harbor project has been proposed for Hilo Harbor. (A 38-foot project depth plus 0.8 foot allowance for tide equals the required 4.8 feet underkeel clearance.)

An added problem in Hilo Harbor is the placement of a mooring buoy near the center of the turning basin. The buoy is used exclusively for holding vessels off Pier 1 during surge conditions. The buoy effectively reduces delays and damages caused by heavy surge. However, the turning basin is a Federally maintained project and the buoy prevents full and unrestricted use for which it was designed. A submersible buoy has been proposed to replace the existing fixed structure.

Methodology

The approach used in this analysis was to examine the Statewide sugar industry and determine the most feasible means of exporting Hawaii's raw sugar. This total systems approach evaluated all five of Hawaii's deep-draft ports. It was concluded that Hilo Harbor was the best harbor to deepen to allow optimum use of the deep-draft sugar vessels for topping off before returning to the West Coast. Hilo Harbor was shown to provide the greatest net benefits from a NED standpoint. The following is a summary evaluation of each harbor.

Honolulu Harbor and Barbers Point. The island of Oahu exports the least amount of sugar. This is because most of it is refined on the island for consumption locally. Also, because Oahu is heavily urbanized with little acreage available for sugarcane. The potential or likelihood for last porting here is very small. Oahu ports are the least desirable for deep-draft development to accommodate the larger sugar vessel.

Kahului Harbor. The island of Maui is a large sugar producer. However, Kahului has a solid rock bottom and would be extremely expensive to excavate. It is the next least attractive for last porting.

Nawiliwili Harbor. The island of Kauai is also a high sugar producer. The harbor has a soft bottom and is roughly comparable to Hilo in terms of the extent required to deepen to 38 feet. The port is at one end of the island chain, an advantage shared with Hilo and Kawaihae harbors on the island of Hawaii. Nawiliwili, however, has a very difficult entrance channel ("S" shape configuration) that is not navigable in rough water. Also, the population and economy of Kauai are the smallest of the four major islands and port improvements would not have the greatest total long-term beneficial impact that they would on the larger islands.

Kawaihae Harbor. This port, on the island of Hawaii, is equally attractive as Hilo. The cost of deepening the harbor, however, is significantly greater because of the hard coral bottom which comprises the geology of the site.

Hilo Harbor. The reasons for choosing Hilo are that the harbor has a soft bottom which can be economically excavated. It is at one end of the Hawaiian chain. Hilo is the second largest city in the State of Hawaii. Improvements at Hilo will have the greatest beneficial inmpacts for the most number of people locally as well as producing the greatest net benefits.

In evaluating the economic feasibility of the proposed harbor project, the tangible benefits were determined by (a) considering current port operations and needs, and (b) analyzing the expected future conditions with and without the project. Data used in the evaluation of benefits were obtained from field investigations, interviews with public and private interests and from Federal, State, and local published reports, newspaper articles, and periodicals. The base year of the proposed project was assumed to be 1985, the interest rate used is 7-7/8 percent, and economic life is 50 years.

The development of benefits follows standard Corps of Engineers practice. The value of all goods and services used in the project was estimated at 1982 prices.

Benefits

The primary navigation benefits of the proposed project are transportation cost savings that would be realized by the existing and future domestic sugar vessels that call on Hawaii's ports. The estimated monetary values were based on 1982 price levels and 1985 economic conditions. The projected 1985 economic condition was selected for use in the study since this is the year the recommended project is expected to be operational.

CARGO TRENDS AND PROJECTIONS

The island of Hawaii is served by two major commercial deep-draft ports: Hilo Harbor, located on the northeast coast and Kawaihae Harbor on the west coast. Hilo Harbor, which fronts the city of Hilo, was constructed in 1930 and is the second largest deep-draft port in the State. Hilo is also the second largest city in the State of Hawaii and is the center of economic activity on the island. Within the last decade, an average annual cargo of more than 1,000,000 short tons passed through Hilo Harbor. Principal imports at Hilo include general cargo and petroleum products. Principal exports include sugar and molasses. Kawaihae Deep-Draft Harbor, constructed in 1957, is approximately 85 nautical miles northeast of Hilo. The harbor provides major services to sugar plantations on the western half of the island. In 1978, the harbor handled over 500,000 short tons of cargo of which over one-third was sugar and molasses. General cargo shipments received at Kawaihae Harbor cover a broad, even spectrum with no one import dominating the statistics. Sugar and molasses are the principal export items from Kawaihae. Bulk sugar and molasses are transshipped to the mainland for processing. Table H-1 gives a breakdown of the total cargo traffic through both harbors from 1966 to 1978.

Table H-1. Total Cargo Traffic to Hilo and Kawaihae Harbor 1/ Hawaii County (1966-1978), Short Tons

Year	Hilo	Kawaihae
1966	835,029	266,894
1967	882,535	265,625
1968	991,111	342,614
1969	990,476	317,415
1970	1,141,163	329,425
1971	1,064,384	355,546
1972	1,108,067	303,116
1973	1,041,647	385,850
1974	928,619	291,036
1975	1,053,879	279,687
1976	995,544	263,562
1977	1,013,430	318,197
1978	1,272,734	502,451

1/ Waterborne Commerce of the United States, Department of the Army, Corps of Engineers.

Petroleum

Total energy consumption in the State of Hawaii increased at an average annual rate of 9 percent from 1934 to 1974, compared with a 2 percent annual growth rate in population. From 1975 to 1978, conservation in energy consumption resulted in a somewhat slower increase of about 3 percent a year compared with a 2.4 percent growth rate in population. Petroleum imports on the Big Island of Hawaii increased from 136,100 short tons in 1965 to 225,174 short tons in 1978, representing a 4.0 percent annual rate of growth. The bulk of the petroleum imported to the Big Island is transshipped by barge from Honolulu. During this 13-year period, the population of Hawaii County grew at an annual rate of 2.1 percent for a 31 percent increase. The growth rate of per capita energy consumption for this period was 2.3 percent. Total potential petroleum shipments to Hawaii County were projected (Table H-2), based on the future per capita consumption growth rate used in the petroleum demand study conducted by Tudor Engineering Co. and II-F population projects available from the Department of Planning and Economic Development (DPED).

Table H-2. Petroleum Energy Equivalent Consumption Projections for Hawaii County

Year	Total Projected Shipments to Hawaii County (Short Tons)	Population 2/	Energy Projections in Equivalent Petroleum Tons Per Capita 4/
1978	225,174 1/	80,900 3/	2.78 5/
1980	263,709	92,053 6/	2.86
1985	292,600	95,200	3.08
1990	347,600	105,000	3.31
1995			3.57
2000	461,300	123,300	3.75
2010	571,300	138,000	4.14
2020	674,300	155,000	4.35
2025			4.46
2030	776,000	174,000	4.46
2035	820,100	184,000	4.46

1/ Actual - from Waterborne Commerce of the U.S.
2/ From II-F projections, DPED (modified to include 1980 census estimate).
3/ Actual - Hawaii Data Book (1979).
4/ Based on Tudor Engineering Study, per capita energy consumption will increase at the following rates:

1975-1995	1.5 percent per year
1995-2010	1.0 percent per year
2010-2025	0.5 percent per year
2025-2035	No increase

5/ Actual - 225,174 - 80,900 = 2.78.
6/ 1980 Census.

Future petroleum imports to Hilo Harbor are based on this projection of total petroleum shipments to Hawaii County, historical records, and population estimates. Historical trends indicate that over a 13-year period from 1966-1978 (Table H-3), an average of 92 percent of the total shipments to Hawaii County were handled at Hilo Harbor. Therefore, taking 92 percent of the projected total shipments to Hawaii County gives us an estimate of the total shipments to Hilo Harbor (Table H-4).

Table H-3. Petroleum Inshipments to Hawaii County (1965-1978)

Year	Total Inshipments To Hilo (Short Tons)	% of Total	Total Inshipments To Kawaihae (Short Tons)	% of Total	Total Inshipments To Hawaii County (Short Tons)
1965	145,400	100			145,400
1966	174,847	94	11,433	6	186,280
1967	157,074	90	16,698	10	173,772
1968	209,245	90	23,204	10	232,449
1969	280,085	92	23,162	8	303,247
1970	337,166	90	38,879	10	376,045
1971	285,996	88	38,541	12	324,537
1972	308,398	89	38,511	11	346,909
1973	240,226	92	19,756	8	259,982
1974	235,625	93	18,735	7	254,360
1975	243,042	94	14,331	6	257,373
1976	234,305	95	12,071	5	246,376
1977	236,115	95	11,521	5	247,636
1978	209,623	93	15,551	7	225,174
		92%		8%	

Table H-4. Future Petroleum Inshipments To Hilo Harbor Short Tons

Year	Total Inshipments 1/ To Hawaii County	Total Inshipments 2/ To Hilo Harbor
1980	263,709	242,600
1985	292,600	269,200
1990	347,600	319,800
2000	461,300	424,400
2010	571,300	525,600
2020	674,300	620,400
2030	776,000	713,900
2035	820,100	754,400

1/ From Table H-2.
2/ Based on 92 percent of total inshipments to Hawaii County.

The County of Hawaii is making efforts to reduce its reliance on imported energy which is currently 62 percent of the total island energy consumption. Studies and experiments on alternative energy sources, including biomass, geothermal, and oceanthermal, are being conducted to determine their feasibility. It is conceivable that the majority or possibly all of the future electric power could be generated from these alternate energy sources. The reduction in petroleum consumption could be significant since electrical power generation consumes approximately 33 percent of the island petroleum demand. The remaining petroleum is used for land, water, and air transportation.

General Cargo

Major import items handled through Hilo Harbor include fabricated metal products, general commodities, and construction materials. Cargo inshipments to the Big Island increased from 246,582 short tons in 1966 to 720,359 short tons in 1978. During this same period, cargo inshipments to Hilo increased from 212,538 short tons to 579,230 short tons, representing roughly 85 percent of all general cargo traffic to Hawaii County. In 1978, outshipments at Hilo Harbor remained relatively unchanged from 1966, with sugar and molasses accounting for about 78 percent of all export items.

Projections of inshipments of general cargo for consumption on the Big Island have been constructed by analyzing historical trends and relationships. Multiple regression analysis was performed on 24 years of data for the Hawaii State ports in order to relate the dependent variable of cargo inshipments to an array of independent variables. (Inter-Island Navigation Facilities Demand by Pacific Analysis Corporation 1976) (Proceedings Twenty-first Annual Meeting Transportation Research Forum 1980, page 298-310.) Among the dozens of models developed, the following model works equally well for each of the major islands in the State and is considered to be the most reasonable and reliable, meeting the criteria of (1) good statistical fit with historical data, (2) incorporation of independent variables that have a logical relationship to the dependent variable and (3) independent variables that can be reasonably projected for the next 50 years.

C $= 28.6 \text{ (PURPWR)}^{0.5} + 1382 \text{ (TOUR)}^{0.5} - 116{,}188$

(R-SQ .9/57; STD E of E 6701/; F RATIO 1219) ANOVA

Where C = inshipment tonnage of general cargo to Hawaii County

PURPWR = resident population x per capita income at 1967 price levels

TOUR = hotel rooms x occupancy rate

Table H-5 shows the estimated general cargo inshipment tonnages using this model and the input data, including projections of population, per capita income and tourism.

Table H-5. Projections of Waterborne General Cargo Inshipments Hawaii County

Year	Population	Per Capita Income ($)	Purchasing Power (10^3)$	Tourism	Inshipment Tonnage (10^3)
1985	95,000	4,321	410,000	7,067	579
1990	105,000	4,824	507,000	9,778	664
2000	123,000	5,655	696,000	14,125	802
2010	138,000	6,611	912,000	14,125	912
2020	155,000	7,819	1,212,000	14,125	1,044
2030	174,000	9,253	1,610,000	14,125	1,196
2035	184,000	10,064	1,852,000	14,125	1,279

Future inshipments of general cargo to Hilo Harbor were based on historical trends and a projection of total general cargo inshipments to Hawaii County. During the 13-year period from 1966 to 1978, an average of 85 percent of the total inshipments to the Big Island were handled at Hilo Harbor (see Table H-6). Therefore, taking 85 percent of the projected total shipments to Hawaii County will give us the projected shipments to Hilo Harbor (Table H-7).

Table H-6. General Cargo Inshipments to Hawaii County (1965-1978)

Year	Total Inshipments To Hilo (Short Tons)	% of Total	Total Inshipments To Kawaihae (Short Tons)	% of Total	Total Inshipments To Hawaii County (Short Tons)
1965	209,293	100	-	-	209,293
1966	212,538	86	34,044	14	246,582
1967	193,664	79	36,254	21	229,918
1968	204,905	83	42,112	17	247,017
1969	247,873	84	48,995	16	296,868
1970	324,655	83	64,664	17	389,319
1971	324,687	87	48,241	13	372,928
1972	375,996	85	64,315	15	440,311
1973	328,850	86	55,460	14	384,310
1974	264,116	85	47,136	15	311,252
1975	362,607	89	45,697	11	408,304
1976	336,816	89	42,069	11	378,885
1977	335,365	85	57,272	15	392,637
1978	579,230	80	141,129 1/	20	720,359
		85%		15%	

1/ The significant jump in total inshipments to Kawaihae in 1978 is almost entirely the result of the increase in shipments of motor vehicles, parts, and equipment. In 1977, the port received 9,203 short tons of these commodities. In 1978, total receipts were 87,038 short tons for an increase of 77,835 short tons. In Hilo Harbor, the increase in inshipments was relatively evenly distributed among all commodities.

Table H-7. Future General Cargo Inshipments to Hilo Harbor (Short Tons)

Year	Tons
1985	492,500
1990	564,500
2000	682,000
2010	775,100
2020	887,200
2030	1,016,300
2035	1,087,000

Agriculture

Agriculture is not the predominant source of income for the State it once was, but it still ranks 3rd behind only tourism and military expenditures. Tourism contributed an estimated $3 billion to the Hawaiian economy while Federal defense expenditures accounted for $1.34 billion in 1980. Sales from agricultural products totaled $1.013 billion in the same year. Sugar accounted for over 62 percent of this with $631 million in sales, pineapple 21 percent or $213 million. Diversified agriculture representing the remainder accounted for 17 percent or $169 million.

Table H-8. Value of Agricultural Sales (1,000 dollars)

Year	Sugar	Pineapple	Diversified Agriculture 1/	Total Crops and Livestock
1977	144,200	62,249	53,715	325,182
1978	182,700	63,090	62,308	380,655
1979	217,600	69,409	75,780	441,253
1980	385,100	76,596	91,181	634,101
1981	207,400	89,745	104,103	489,435

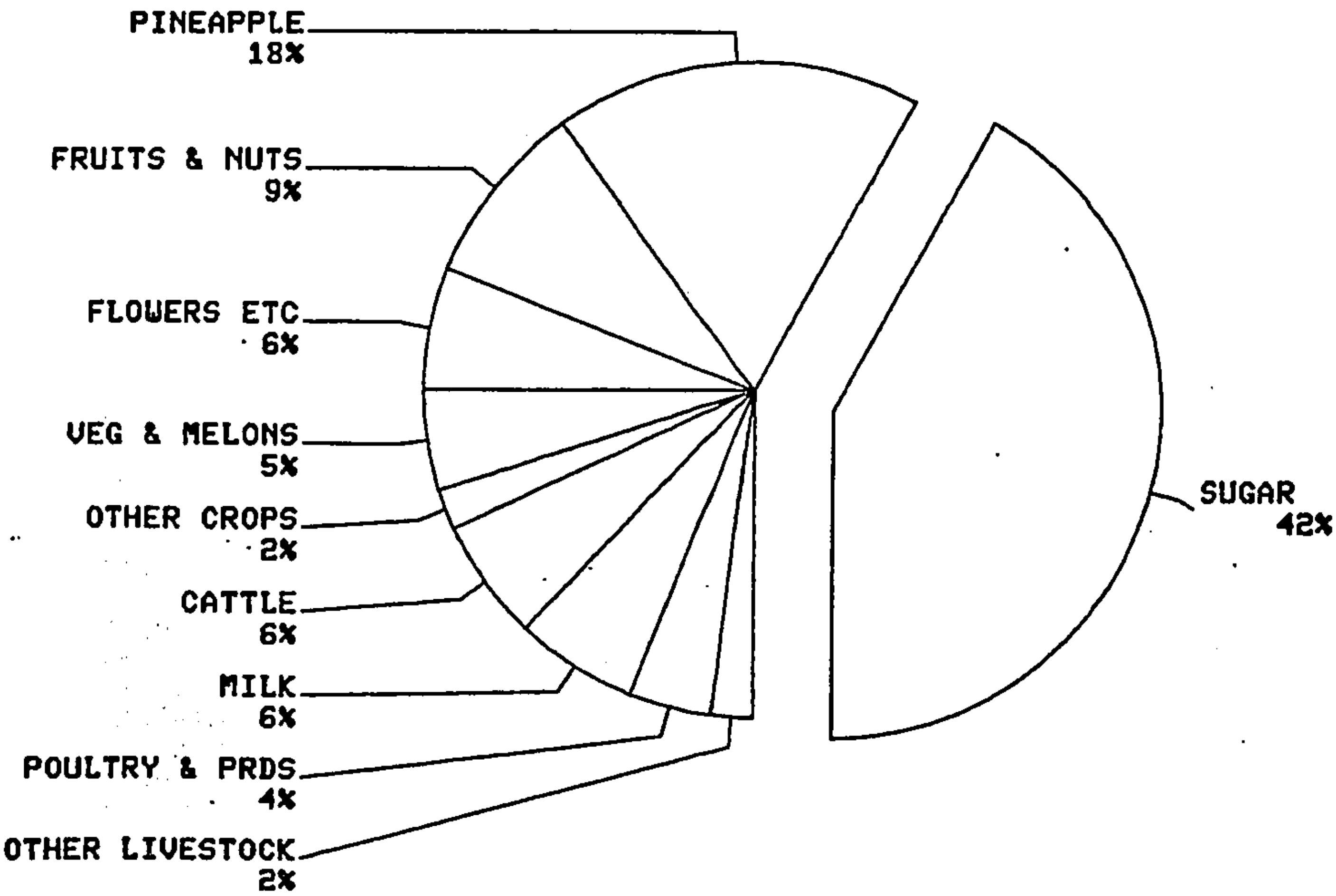
1/ Includes: Vegetables, melons, fruits (excluding pineapple), coffee (parchment), macadamia nuts, taro, miscellaneous crops, flowers and nursery products.

Source: Statistics of Hawaiian Agriculture 1981, Hawaii Department of Agriculture and U.S. Department of Agriculture.

As Table H-8 clearly shows the significant decrease in agricultural sales in 1981 was caused entirely by the sugar industry. The low price of sugar in 1981 caused the farm value of agriculture to plunge 23 percent from a record high the previous year. However, the value of the sugar industry to the State is still paramount as evidenced graphically by Figure H-1.

Figure H-1.

STATE OF HAWAII AGRICULTURAL VALUE RATIOS 1981
(VALUE OF SALES)



Hawaii Sugar

Sugarcane has been harvested in Hawaii at least since 1778 when it was observed growing by Captain James Cook on his discovery visits. Historians believe that this important food plant was brought to Hawaii by the Polynesians some 800 years before Cook. However, sugar was not successfully milled in Hawaii until 1837 when 5,039 pounds of sugar and 400 pounds of molasses were sent out by ships in that year.

In 1876 after negotiation of the Reciprocity Treaty, sugarcane growing expanded rapidly. By the time Hawaii became a territory of the United States in 1886, production had reached 100,000 tons, it quickly grew to 250,000 tons by 1897. Total tonnage doubled again 11 years later to 500,000 tons in 1908. In 1981, a total of 1,048,000 tons of raw sugar and 312,000 tons of molasses were produced in Hawaii.

Table H-9. Production of Raw Sugar by Counties (1960 - 1981)

Year	Hawaii	Kauai	Maui	Oahu	State
1960	345,000	194,000	215,000	182,000	936,000
1961	376,000	249,000	255,000	212,000	1,092,000
1962	393,000	258,000	250,000	219,000	1,120,000
1963	374,000	261,000	243,000	224,000	1,101,000
1964	427,000	266,000	265,000	221,000	1,179,000
1965	456,000	273,000	279,000	210,000	1,218,000
1966	420,000	273,000	303,000	238,000	1,234,000
1967	440,000	258,000	281,000	212,000	1,191,000
1968	455,000	264,000	281,000	225,000	1,232,000
1969	439,000	257,000	269,000	217,000	1,182,000
1970	431,000	239,000	280,000	212,000	1,162,000
1971	465,000	256,000	292,000	217,000	1,230,000
1972	423,000	242,000	278,000	176,000	1,119,000
1973	423,000	246,000	268,000	192,000	1,129,000
1974	390,000	227,000	260,000	164,000	1,041,000
1975	412,000	240,000	261,000	194,000	1,107,000
1976	388,000	216,000	263,000	183,000	1,050,000
1977	374,000	232,000	265,000	163,000	1,034,000
1978	388,000	223,000	245,000	173,000	1,029,000
1979	388,000	233,000	253,000	186,000	1,060,000
1980	367,000	223,000	266,000	167,000	1,023,000
1981	384,000	236,000	255,000	173,000	1,048,000

Source: Statistic of Hawaiian Agriculture, various years, Hawaii Department of Agriculture and U.S. Department of Agriculture.

Hawaii's sugarcane industry is unlike all the other sugarcane producers of the world in two important respects. (1) The harvest season is virtually year-round except for the one to two months each year when the sugar mills suspend operations for maintenance and overhauling. (2) The age of the sugarcane crop at harvest averages two years. About one-half of the sugar lands are harvested each year.

Hawaii's sugar industry is also one of the most advanced technologically in the world. Heavy investments in state-of-the-art field machinery and factory processing equipment and controls have made Hawaii's sugarcane workers the most productive in the world as well. The average sugarcane yield in 1980 was 94.64 short tons per acre. This is three to four times the average yield for Louisiana, Florida and Texas, the other major sugarcane producers in the United States.

In 1980, the Hawaii sugar industry employed over 7,000 sugar workers in the fields and factories. The annual payroll amounted to $138,168,000.

About 95 percent of Hawaiian sugar is shipped to the U.S. mainland for refining and marketing. The remainder is refined at C&H Sugar Company refinery in Aiea, Hawaii on the island of Oahu. The final Aiea product is primarily for Hawaiian consumption.

The raw sugar is shipped in bulk form. The bulk sugar is loaded on ships at the deep-draft ports of Kahului, Maui; Hilo and Kawaihae, Hawaii; Honolulu, Oahu; and Nawiliwili, Kauai. There were 56 voyages of ships carrying raw sugar from Hawaii to the refinery in Crockett, California, in 1980.

The total acreage employed for growing sugarcane in Hawaii is about 220,000 acres or about 5 percent of the total land area. Approximately 55 percent of the sugar lands are owned by the sugar companies. The other 45 percent are leased from government or private owners.

Table H-10. Hawaiian Sugar Companies by Islands, with Acreage and Production for 1980 (Raw Value)

	Total Caneland Acreage	Acreage Harvested	Production (short tons)	Tons Sugar Per Harvested Acre
HAWAII				
Hilo Coast Processing Co. (Processor only)			105,364 1/	9.54
Mauna Kea Sugar Co. (Grower only)	16,793	7,690		
United Cane Planter Coop. (Grower only)	6,825	3,351		
Davies Hamakua Sugar Co.	35,507	14,431	141,892	9.83
Ka'u Sugar Co., Inc.	15,905	4,829	63,181	13.08
Puna Sugar Co., Ltd.	16,172	7,073	56,609	8.00
TOTAL HAWAII	91,202	37,374	367,046	9.82
KAUAI				
Gay and Robinson (Grower only)	2,628	1,299	16,811 2/	12.94
Kekaha Sugar Co., Ltd.	8,177	3,774	48,651	12.89
The Lihue Plantation Co.	17,308	8,718	74,009	8.49
McBryde Sugar Co., Ltd.	13,015	6,343	54,710	8.63
Olokele Sugar Co., Ltd.	4,841	2,327	28,487	12.24
TOTAL KAUAI	45,969	22,461	222,668	9.91
MAUI				
Hawaiian Commercial & Sugar Co.	34,727	15,356	188,004	12.24
Pioneer Mill Co., Ltd.	8,599	4,638	49,842	10.74
Wailuku Sugar Co.	4,089	2,505	28,405	11.34
TOTAL MAUI	47,415	22,499	266,251	11.83
OAHU				
Oahu Sugar Co., Ltd.	18,188	9,286	104,350	11.24
Waialua Sugar Co., Inc.	14,944	5,738	62,917	10.96
TOTAL OAHU	33,132	15,024	167,267	11.13
TOTAL--ALL ISLANDS	217,718	97,358	1,023,232	10.51

1/ 80,121 tons attributed to Mauna Kea Sugar Co.; 25,243 tons attributed to United Cane Planters Coop.
2/ Gay & Robinson sugarcane milled by Olokele Sugar Co., Inc.

Source: "Hawaiian Sugar Manual 1981," Hawaii Sugar Planters' Association.

Sugar Projections

The sugar industry in Hawaii experienced substantial growth, although very erratic at times, during the 1940's, 1950's and halfway through the 1960's. A two-and-a-half month strike in 1946 and a four month long industry-wide strike in 1958 drastically reduced the production in those years (Figure H-2). The impact of the strike in each case lasted several years. As Figure H-2 shows, it took as long as three years for sugar production to reach the annual levels prior to the strikes.

From 1965 to 1971 sugar production reached the highest levels in the history of the industry. A record raw sugar crop of 1,234,121 tons was produced in 1966.

Smut disease was discovered in the sugar fields on Oahu in 1971. This spread to the neighbor islands and led to a continuous decline in production until 1975. Since 1975, sugar production has been relatively stable at about 1.05 million tons annually.

The outlook for the sugar industry in Hawaii for the next several years is in a period of transition making adjustments to new market conditions created by changed Federal policies. This is explained in more detail in the following paragraphs. In 1981, sugar production was 1.05 million tons up 3 percent from 1.02 million tons the preceding year. The acreage harvested remained virtually the same at 97.6 thousand acres. However, world prices for sugar continued to sink in 1981 resulting in millions of dollars in losses for the sugar industry. The processed value of sugar and molasses totaled $327.9 million, down 45 percent from the record high of $594.1 million in 1980. Unable to overcome the financial losses some of the sugar plantations have indicated they will shut down or convert acreage to alternative uses. To date, the Puna Plantation on the Big Island announced that it will cease sugar shipments by 1984. As well, the Mauna Kea Sugar Company plans to turn 8,000 acres of cane fields into macadamia nut orchards over the next 10 years. The overall impact as estimated by the Hawaii Sugar Planters' Association (HSPA) will be an estimated gradual decline in production on the Big Island of 85,000 tons annually by 1992. (The

PROJECTIONS OF CANE SUGAR PRODUCTION IN HAWAII
1985 - 2035

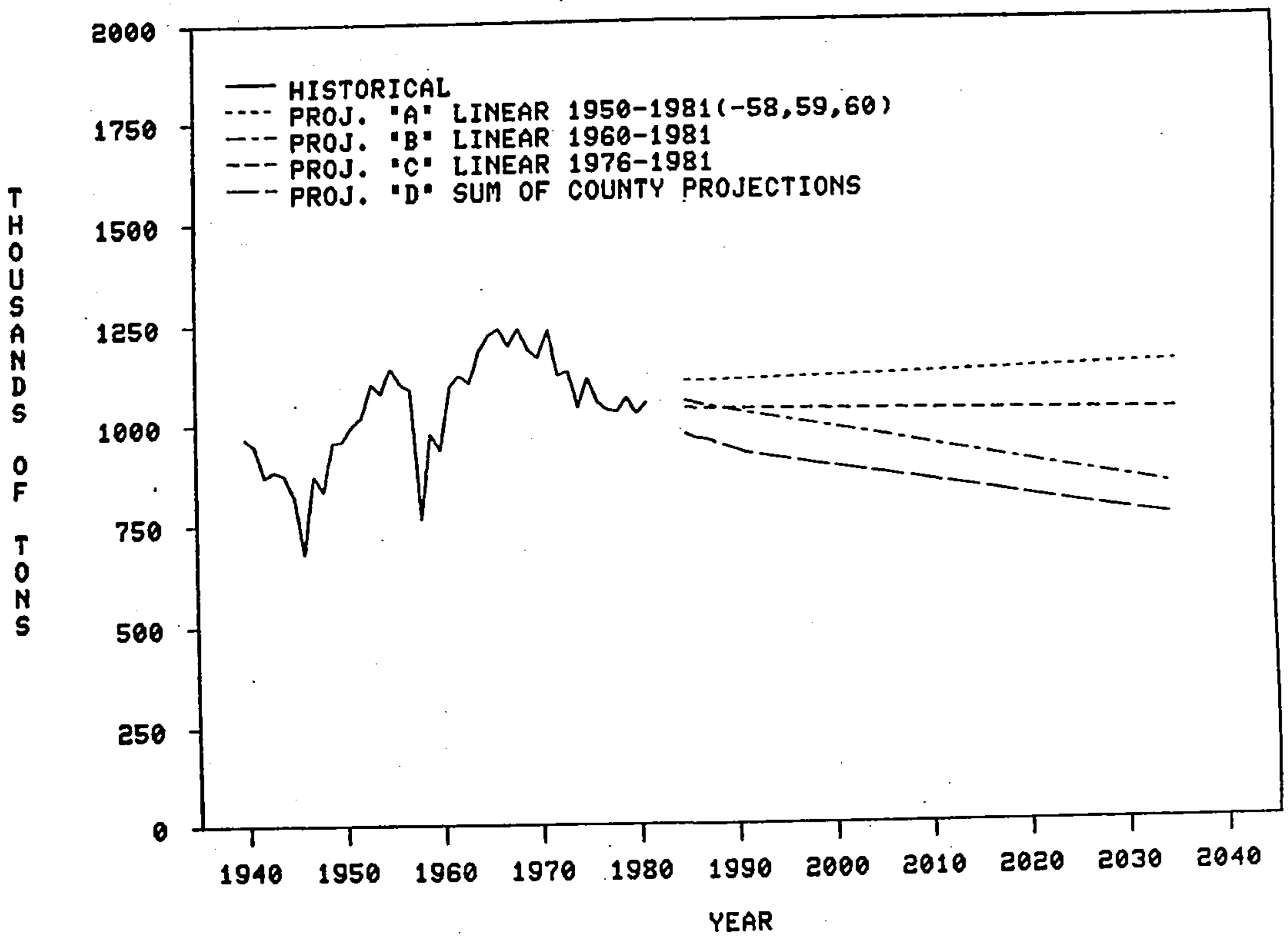


Figure H-2

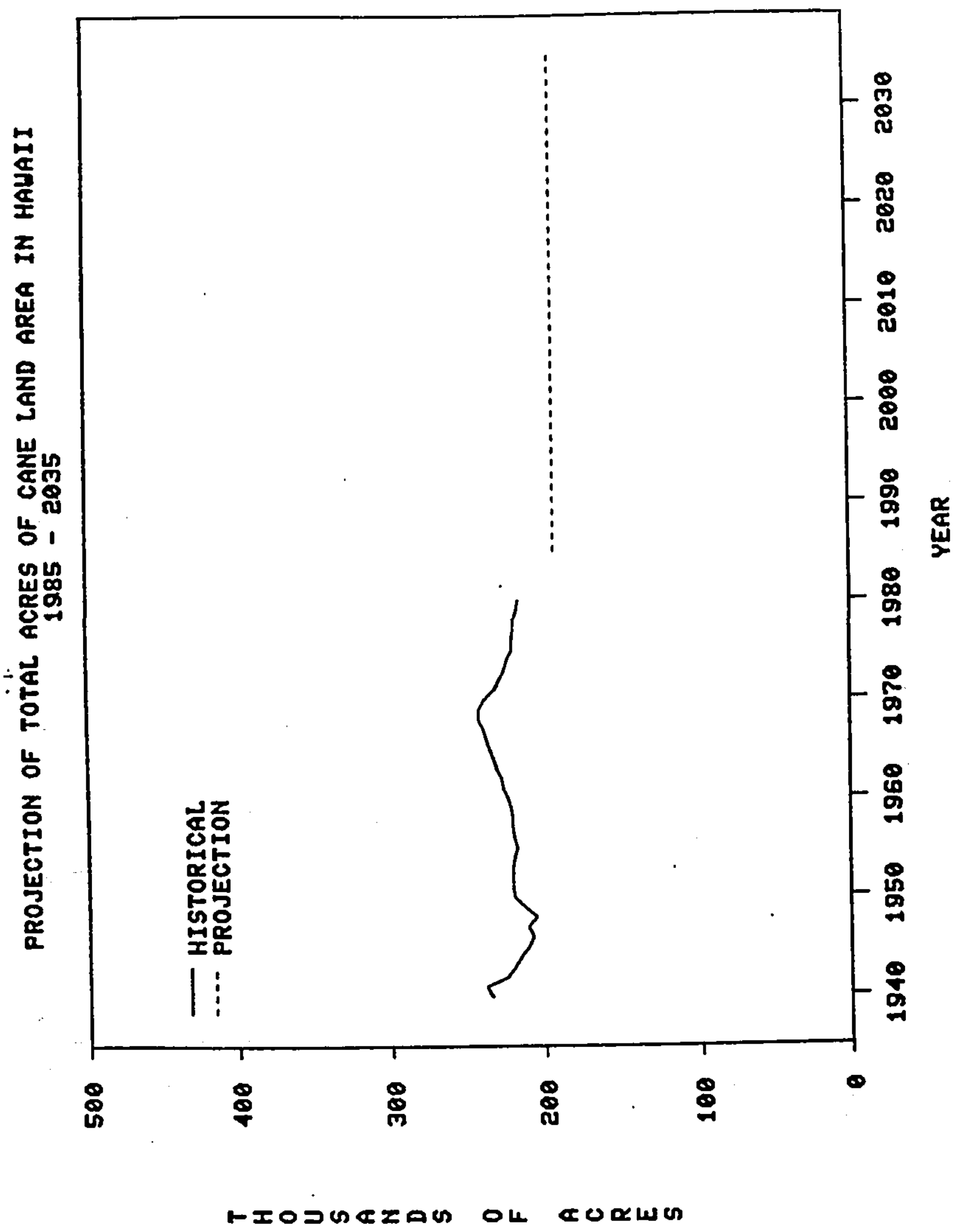
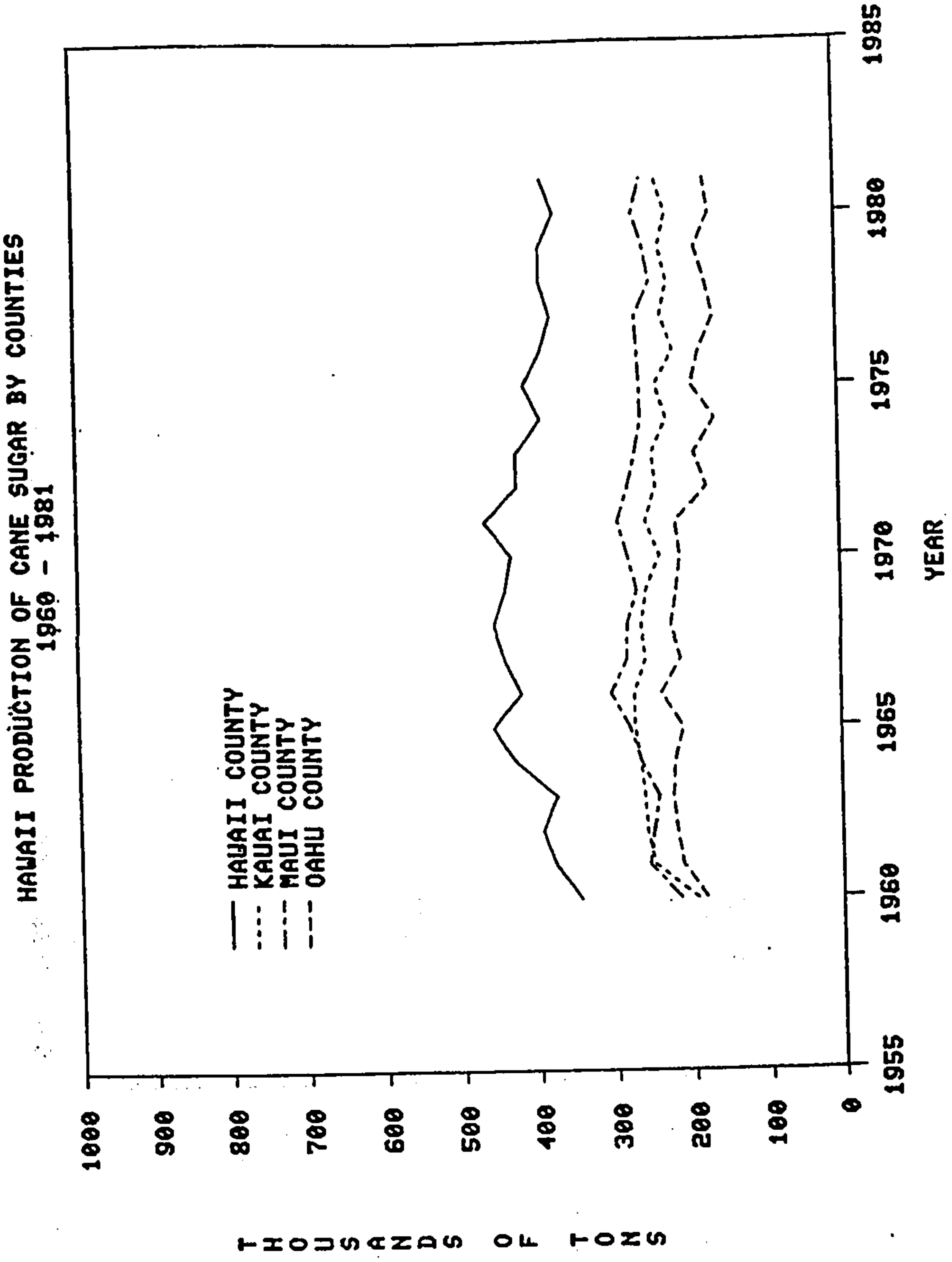

PROJECTION OF TOTAL ACRES OF CANE LAND AREA IN HAWAII
1985 - 2035
HISTORICAL
PROJECTION
THOUSANDS OF ACRES
0
100
200
300
400
500
YEAR
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030

Figure H-3

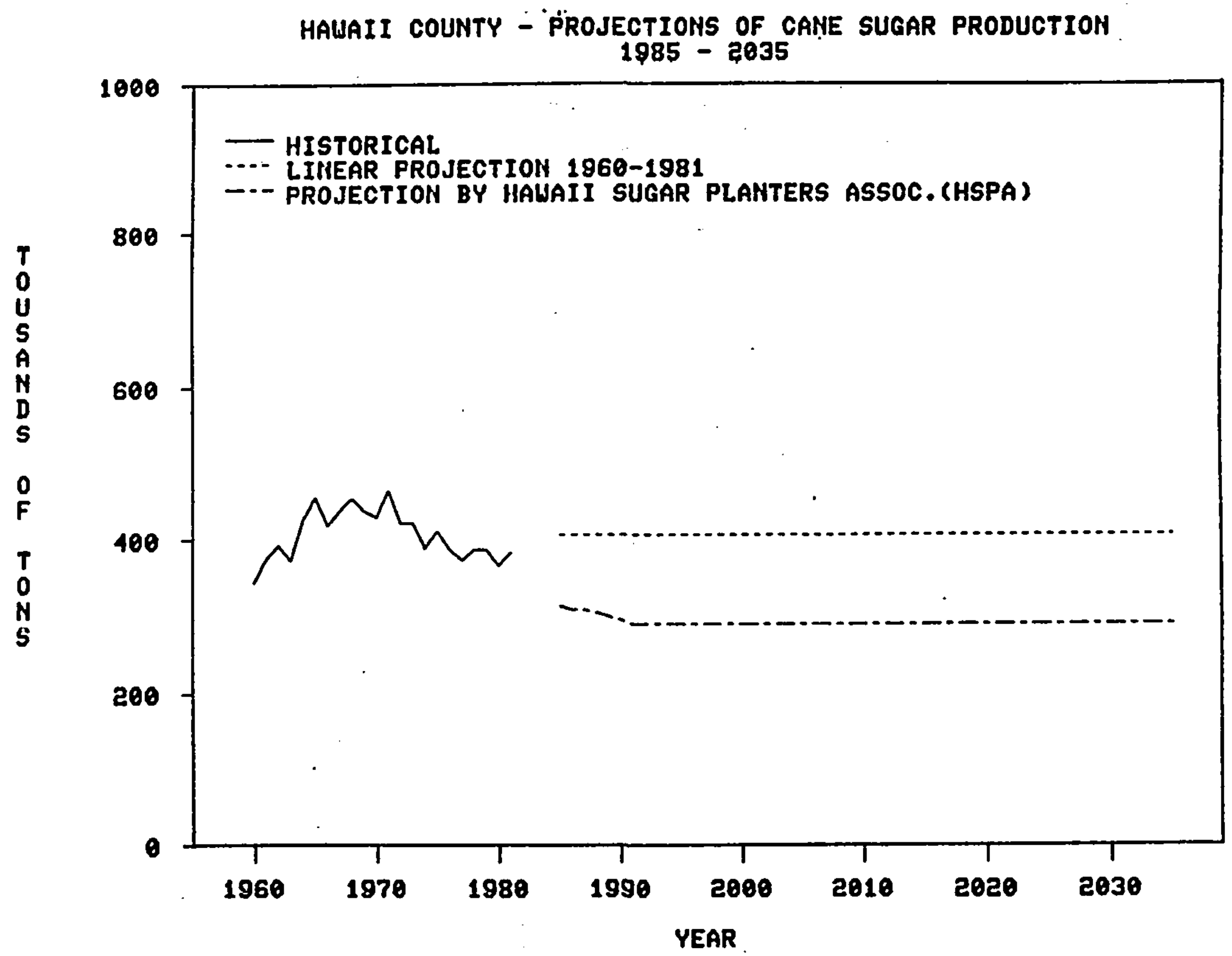


HAWAII PRODUCTION OF CANE SUGAR BY COUNTIES
1960 - 1981
HAWAII COUNTY
KAUAI COUNTY
MAUI COUNTY
OAHU COUNTY
THOUSANDS OF TONS
1000
900
800
700
600
500
400
300
200
100
0
1955
1960
1965
1970
1975
1980
1985
YEAR

Figure H-4

actual decrease in production will be offset somewhat by an estimated 10 percent increase in yield because of a new blight resistant strain of sugar coming on line.) In an attempt to bring relief to the industry the Congress last year passed the Farm Act which set a floor price for a pound of sugar. In May 1982 the Federal Administration, as well, imposed import quotas. These actions have, at least in the short term, raised domestic sugar prices to the break-even level.

Various projections of Hawaii's future sugar production have been prepared. The projections are linear extrapolations of historical data and present a range of possible future outcomes. Sugar Projection A is an extension of growth exhibited over the last 31 years from 1950 to 1981 minus the years 1958, 1959, and 1960. The four month long industry-wide strike in 1958 severely reduced production in those years. It was not until 1961 before production reached the same levels as before the strike. Sugar Projection B is a linear extrapolation of the years 1960 to 1981. Sugar Projection C is a linear extrapolation of the years 1976 through 1981, the period the U.S. has been without a strong sugar policy. The projection for this period represents stable sugar production for the industry. Projection D is the sum of the linear projections prepared for Kauai, Maui, and Oahu, and HSPA's projection for Hawaii County (see Figure H-5 - H-8). Sugar Projection D presents a very depressed outlook for the industry.



HAWAII COUNTY - PROJECTIONS OF CANE SUGAR PRODUCTION
1985 - 2035
HISTORICAL
LINEAR PROJECTION 1960-1981
PROJECTION BY HAWAII SUGAR PLANTERS ASSOC.(HSPA)
TOUSANDS OF TONS
1000
800
600
400
200
0
1960
1970
1980
1990
2000
2010
2020
2030
YEAR

Figure H-5

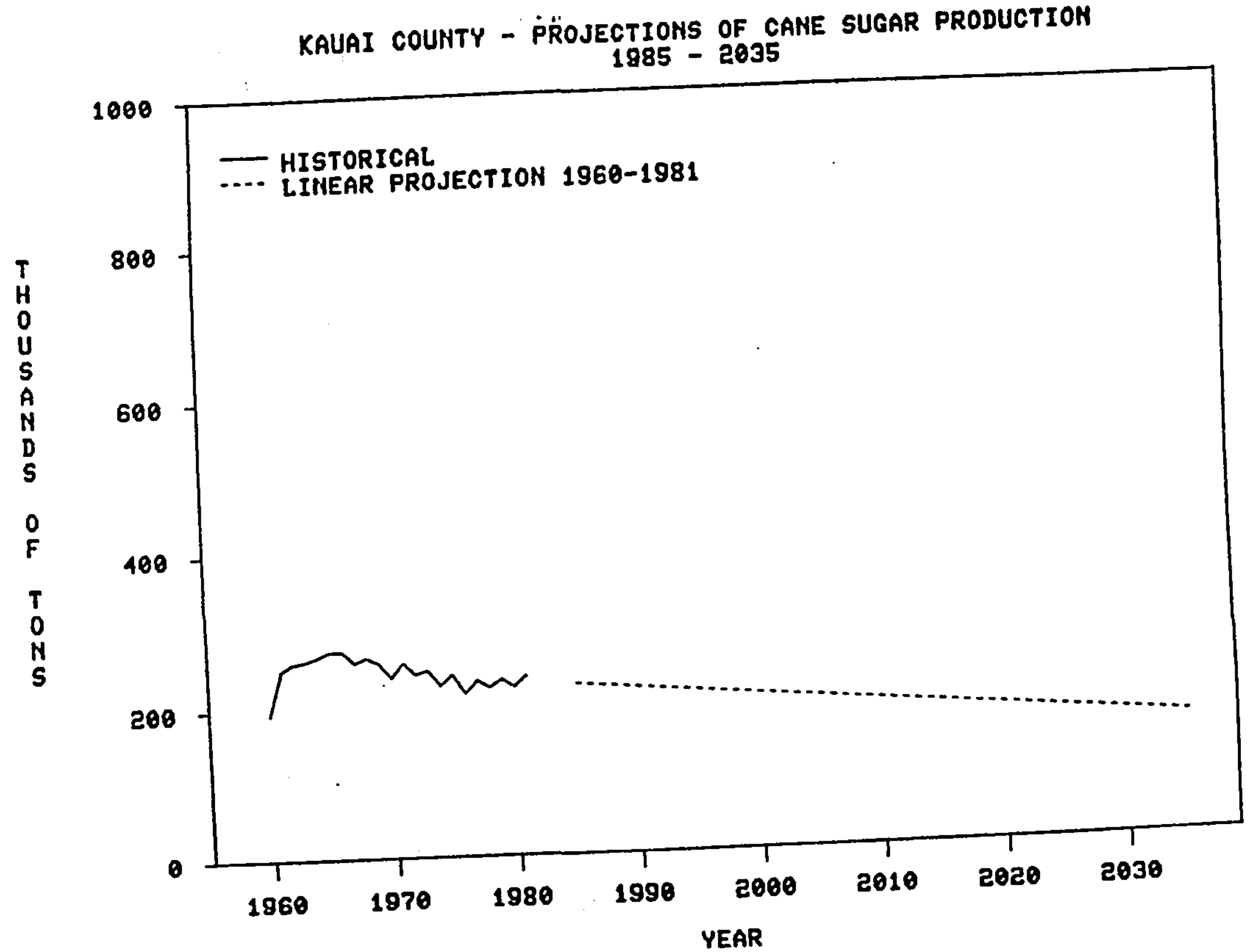

KAUAI COUNTY - PROJECTIONS OF CANE SUGAR PRODUCTION
1985 - 2035
HISTORICAL
LINEAR PROJECTION 1960-1981
THOUSANDS OF TONS
1000
800
600
400
200
0
1960
1970
1980
1990
2000
2010
2020
2030
YEAR

Figure H-6

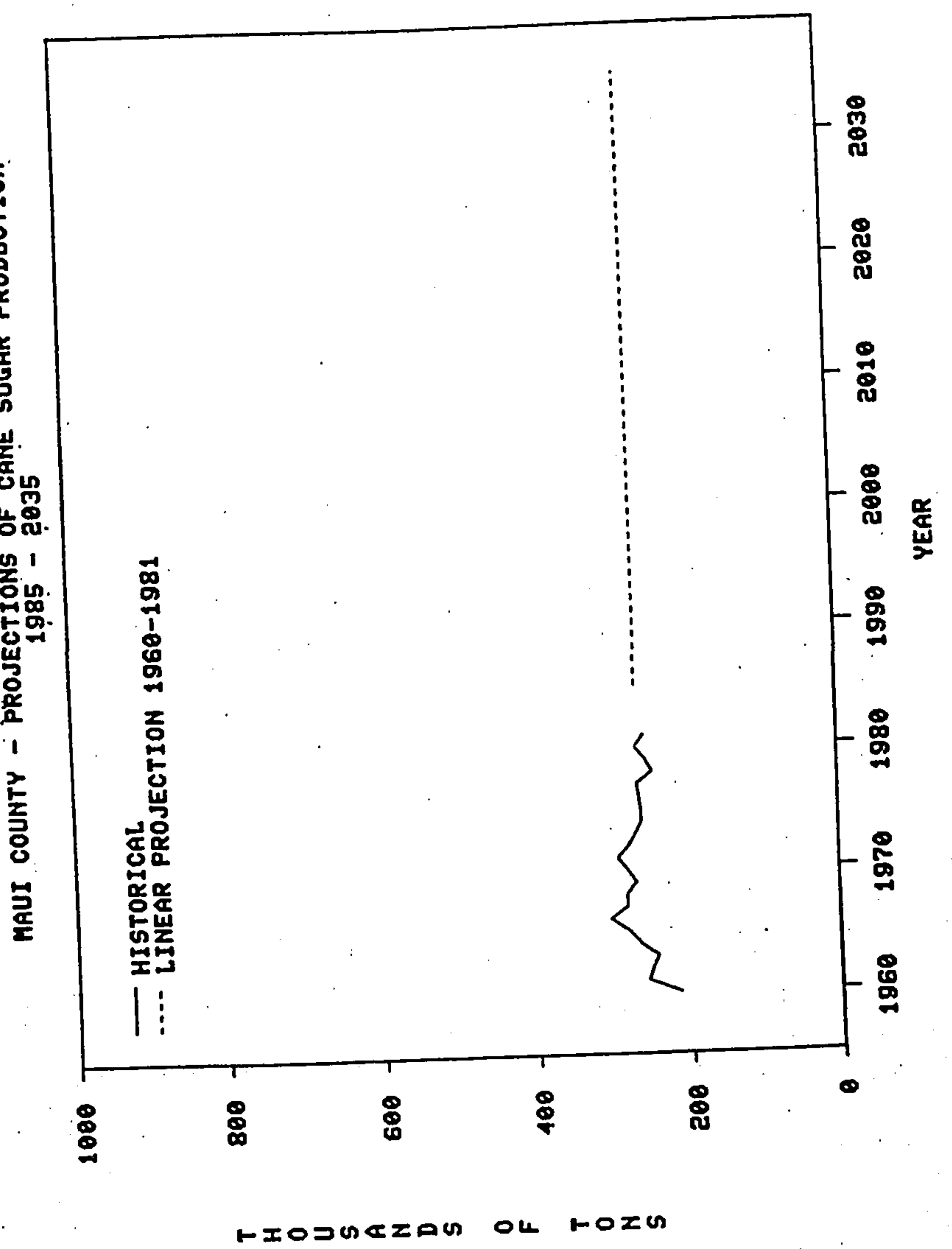

MAUI COUNTY - PROJECTIONS OF CANE SUGAR PRODUCTION
1985 - 2035
HISTORICAL
LINEAR PROJECTION 1960-1981
THOUSANDS OF TONS
0
200
400
600
800
1000
YEAR
1960
1970
1980
1990
2000
2010
2020
2030

Figure H-7

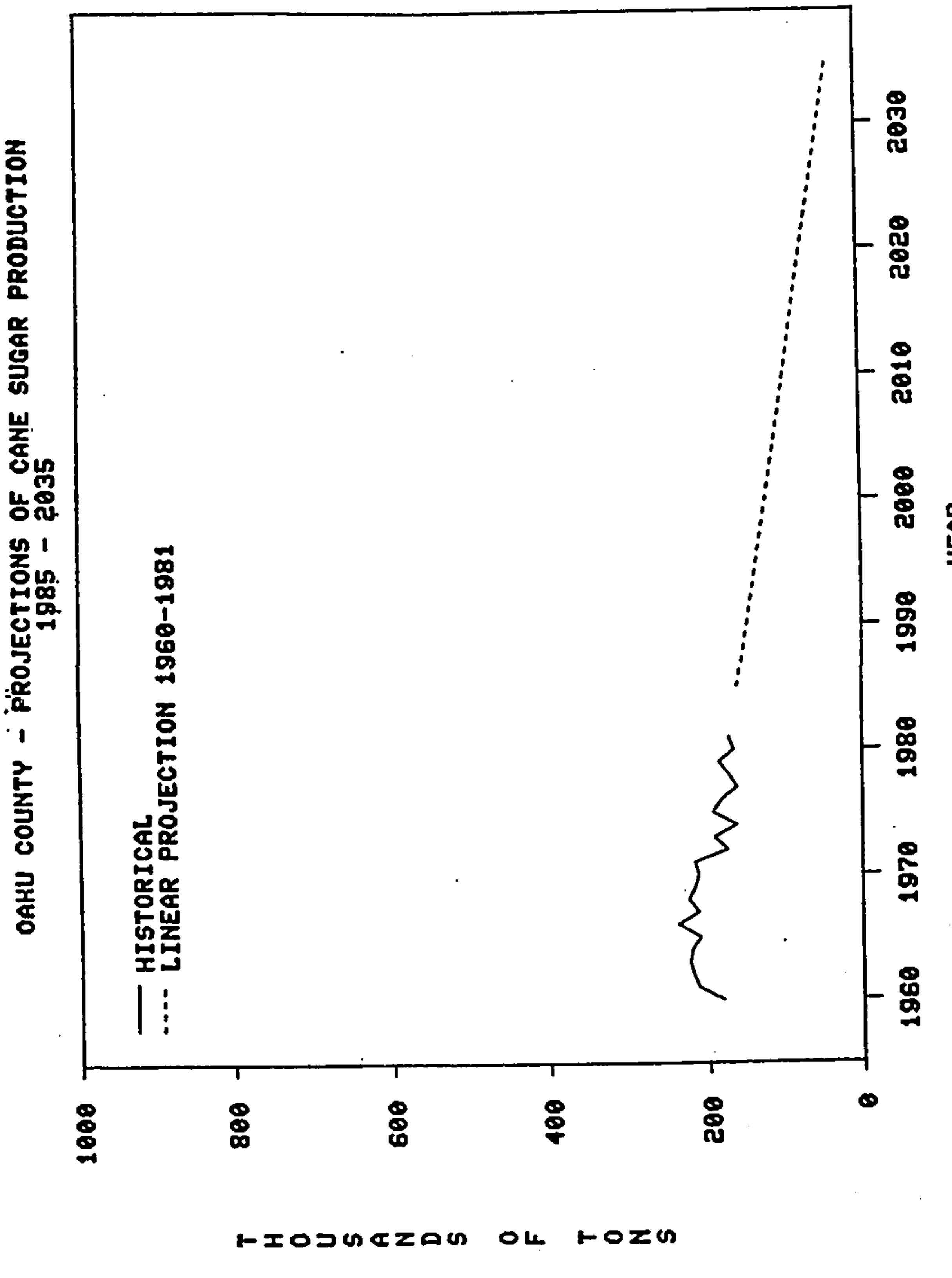

OAHU COUNTY - PROJECTIONS OF CANE SUGAR PRODUCTION
1985 - 2035
HISTORICAL
LINEAR PROJECTION 1960-1981
THOUSANDS OF TONS
1000
800
600
400
200
0
1960
1970
1980
1990
2000
2010
2020
2030
YEAR

Figure H-8

Manganese Nodules

The economic impact of potential manganese nodule mining operations could be significant for the State. Because of the proximity of the State to the belt of high-grade nodules, development of a manganese nodule industry appears attractive for Hawaii. If tests currently underway prove successful, mining of deep-sea manganese nodules southeast of Hawaii could begin within a few years. Initial construction of a processing plant and associated infrastructure would require a capital investment of $521 million. An additional $20 to $24 million would be needed for construction of a power-generating plant. It has been estimated that during the three-year construction phase, the Gross State Product would increase by about $202 million annually and an additional 6,000 new jobs would be created. About 5,000 of these jobs would be available in Hawaii County with 3,000 in the construction industry.

Preliminary feasibility studies have investigated the Puna District on the Big Island as a potential site for the manganese processing facilities. A major requirement for the processing plant will be the availability of energy resources. Scientists have estimated that the Puna area has enough geothermal resources to produce from 400 to 500 megawatts of power.

Approximately 3 million wet (2.25 million dry) metric tons of nodules are expected to be mined and processed annually. This new industry would increase the Gross State Product by $335 million and add an additional 2,400 jobs to the State labor force.

The impact of the manganese nodule industry on Hilo Harbor could be significant. Transport of nodules from the primary mining areas would be by a tug and barge system because of the relatively short distance involved. Based on existing harbor and channel depths of 35 feet at Hilo Harbor, draft restrictions limit the maximum size of a bulk carrier (barge) to about 35,000 DWT. At the Port of Hilo, special storage facilities requiring about 10 acres will be needed to receive nodule shipments. The ocean transportation system will consist of a fleet of four barges with individual capacities of 35,000 DWT. In order to transport the projected 3 million metric tons of manganese nodules, each barge will be required to make 24 trips a year.

FLEET COMPOSITION

Existing Fleet Characteristics

The growth of waterborne commerce within the State of Hawaii has been in an uptrend over the past few years. With a growing population, increased demands for food, fuel, and other major commodities resulted in an upturn in inter-island transportation. Barges, containerships, and tankers provide the major modes of travel for cargo destined for Hilo Harbor.

Barge - General Cargo

Barge traffic through Hilo Harbor during 1978 represented approximately 60 percent of all incoming vessel traffic. (The names of individual shipping companies and vessels will not be used in this appendix to avoid any possible disclosure of confidential information. Company and vessel or barge names have been replaced when necessary with a number and letter.) There are seven companies that operate barges; the largest currently brings in general cargo to Hilo Port. Recent trends in shipping have tended towards containerized cargo, and in 1979, 59,141 revenue tons or 26 percent of all general cargo brought in by one company was containerized. The predominant size container used is 20 feet. The barges used have a rated capacity ranging from 2,000 to 3,700 tons and a maximum draft between 6 and 7 feet. Existing service to Hilo is provided three times a week.

A second company, with main headquarters in the Pacific Northwest, imports lumber and wood products to the State. Its existing operation at Hilo port consists of movement by tug and tandem barge. These barges, which call on Hilo Harbor once a month, have rated capacities from 3,600 - 5,400 tons and fully loaded draft of 14 feet.

A third company provides most of the fertilizer and chemical products consumed in Hawaii County. Tug and barge operations are being utilized to deliver dry bulk shipments of fertilizer as well as other chemical products. Existing service to Hilo is provided 6 times a year by a 15,500-ton capacity barge.

A fourth company, with its own barge operation, calls on Hilo Harbor approximately 18 times a year with a full load of cement for the local construction industry. Total in-port time spent by barges for unloading and loading cargo was available from the Department of Transportation (DOT), Harbors Division. Based on these data, the average in-port time for barges can be computed.

Barge - Petroleum

Petroleum and petroleum products are supplied by three major producers. Transshipment of these products is done principally by tug and barge operations. The largest supplier of petroleum brought in approximately 958,000 barrels in 1979, accounting for over 50 percent of the total imports to Hilo. The barge used had a rated capacity of 60,000 barrels and a fully loaded draft of 21 feet. During the past year, this barge made a total of 24 trips or an average of 1 trip about every 2 weeks.

Two other barges are also used to transport petroleum to Hilo Harbor. One of the barges, with a rated capacity of 30,000 barrels, averaged 10,000 barrels per trip in 1979. The barge made a total of 24 trips to Hilo Harbor last year.

The average time spent at berth by petroleum barges was available from DOT records. Since the barges have different capacities, turnaround times will vary given the identical discharge rate at port.

Petroleum Tankers

Sister ships owned and operated by another major oil company are currently the only petroleum tankers calling at Hilo Harbor. Both vessels are 661 feet in length, 90 feet in breadth and have an international summer draft of just under 36 feet. Although the tankers have a maximum draft of almost 36 feet, company officials indicated the tankers have not encountered any major navigational problems at Hilo. Since most of the shipment to Hawaii from the mainland is jet fuel, major deliveries are unloaded to Honolulu Harbor before the remaining load is delivered at Kahului Harbor on Maui and Hilo Harbor. The maximum draft of these tankers is never reached because of sharply reduced loads when entering Hilo Harbor. During the past year, the capacity of these ships did not exceed half of their maximum, 35,000 DWT.

Dry Bulk Carriers

Dry bulk carriers play a major role in Hawaii's export and interisland transportation system. These ships have been used to export bulk sugar as well as servicing Hilo port with general bulk cargo. The existing fleet, used for exporting sugar and molasses, consists of four vessels, the largest with a rated capacity of 31,500 DWT. Other vessels are used intermittently when the need arises. Two vessels will soon be phased out of serving Hilo. The composition of the dry bulk carriers will make further changes with the introduction of the new Integrated Tug and Barge (ITB) scheduled to be put into service in late 1982 (see Future Fleet Characteristics).

Containerships

Major container port operations at Pier 1 involve the loading and unloading of roll-on/roll-off (RO/RO) and load-on/load-Off (LO/LO) vessels. The existing fleet calling at Hilo Harbor consists of two vessels. One vessel (LO/LO) has a capacity of 187 24-foot containers and calls on Hilo Harbor once a week. The other vessel (RO/RO) has a capacity of 293 40-foot containers and an additional 160 autos and calls on Hilo about every other week. The RO/RO vessel is capable of unloading 26 containers and 40 autos per hour. The LO/LO vessel, on the other hand, unloads 20 containers per hour. Based on the above data and the fact that empty containers must be reloaded on the containership, the average turnaround times for the RO/RO and LO/LO vessels are 27 and 19 hours, respectively. A third vessel (RO/RO) has been lengthened to handle lift-on, lift-off containers. The ship will get an additional 126-1/2-foot midbody section, increasing its total length of 826-1/2 feet. The increased length enables the vessel to handle 1,046 24-foot equivalents of trailer and container units compared with its previous capacity of 434 equivalents. The ship is not yet scheduled to serve Hilo Harbor, but could possibly be used to complement the existing fleet in the future.

Interisland Cruise Ships

Congressional authority was recently granted for a passenger cruise ship to serve Hawaii, and interisland cruises began on June 21, 1980. The 750-passenger, 20,300-ton vessel sails from Honolulu, Oahu, and makes full day calls at Hilo and Kona on the Big Island, Kahului on Maui, and Nawiliwili, Kauai. The ship is 682 feet long and draws a maximum loaded draft of 23 feet. A second passenger vessel of similar dimensions has recently been added by the owners of the other ship.

A summary of the existing vessel fleet is shown in Table H-11.

Table H-11. Existing Vessel Fleet 1/ 2/

Company Vessel	Type	DWT	Loaded Draft (Feet)	Length (Feet)
Company No. 1				
Vessels A	Containership	4,400	18' 4"	338'
B	Containership	14,000	28' 1"	700'
C	Bulk Carrier	18,500	32'	630'
D	Bulk Carrier	18,500	32'	630'
E	Bulk Carrier	24,000	33' 8"	595'
F	Bulk Carrier	31,500	33' 10"	641'
G	Bulk Carrier	24,400	32' 6"	626'
H	Bulk Carrier	24,400	32' 6"	626'
Company No. 2				
Vessels I	Tanker	35,000	35' 8"	661'
J	Tanker	35,000	35' 8"	661'
Company No. 3				
Vessel K	Tanker	28,900	29' 5"	492'
Company No. 4				
Vessels L	Passenger Ship	750 passengers	23'	682'
M	Passenger Ship	750 passengers	23'	682'

1/ Companies and vessel names have been replaced with a number and letter to avoid disclosure of confidential information. This policy will be followed where necessary throughout the remainder of this section of the report.

2/ Does not include barge traffic. There are seven companies using barges to Hilo.

FUTURE FLEET CHARACTERISTICS

Future fleet characteristics have been developed from discussions with various shipping agents, industry representatives and the Hilo Harbormaster. Existing vessel fleet size is not expected to grow appreciably over the period of projection.

Barge

Future barge traffic through Hilo Harbor will essentially remain unchanged, and no appreciable increase in vessel fleet or vessel size is anticipated. The only foreseeable change in the barge vessel fleet is the introduction of the new ITB vessel in 1982 and the proposed use of a 60,000 barrel barge.

The ITB is the largest oceangoing barge built in the United States. The new barge is non-self propelled with a specially designed stern for rigid connection to a catamaran tug for pushing. It has a dead weight capacity of 37,200 tons (DWT) and a design draft of 36 feet. Its overall length is just over 684 feet when coupled to the tug, and its beam is 84 feet. The ITB is designed to carry raw sugar, grain, granular fertilizers or similar cargoes in six holds. It is also equipped with four liquid fertilizer tanks, having a total capacity of 216,000 cubic feet.

The ITB will be used primarily to transport sugar from Hawaii to a refinery in California. It will make an estimated 16 trips annually. Routinely, the vessel will stop first at Hilo or Nawiliwili and then proceed to other ports along the Hawaiian chain to load sugar. The ITB will also be used to backhaul fertilizer approximately four trips a year.

Tankers

Continued use of the existing tankers is anticipated according to oil company representatives. Because of the limited demand and through-put capacity at Hilo Harbor, a trend towards the usage of large tankers is not envisioned at this time.

Dry Bulk Carriers

The ITB vessel and two other bulk carriers will handle future shipments of sugar beginning in November 1982. Since the production of sugar during the period of projection is expected to remain relatively unchanged, the required number of trips needed to transport this commodity will remain constant. No decision has been made concerning the handling of future molasses shipments.

Containerships

Continued use of the two existing containership vessels is anticipated over the period of projection, and an alternate vessel could possibly be used when additional trips are required for extra cargo. Containership vessels have been converting to the relatively new RO/RO type vessel because of more efficient operational capabilities with containerized cargo. Containerization of general cargo is becoming increasingly popular among local shipping companies.

Interisland Cruise Ships

There is only one interisland cruise ship presently in operation. Three other ships have been granted permission to serve Hawaii. Two of these vessels, however, have had to postpone their scheduled start because of financial tie-ups and delays. The other vessel is scheduled for operation shortly.

A summary of the future vessel fleet serving Hilo Harbor is shown on Table H-12.

Table H-12. Future Vessel Fleet 1/ 2/

Company Vessel	Type	DWT	Loaded Draft (Feet)	Length (Feet)
Company No. 1				
Vessels A	Containership	4,400	18' 4"	338'
B	Containership	14,000	28' 1"	700'
Company No. 2				
Vessels C	Bulk Carrier	37,200	36' 0"	684'
D	Bulk Carrier	31,500	33' 10"	641'
E	Bulk Carrier	24,000	33' 8"	595'
Company No. 3				
Vessels F	Tanker	35,000	35' 8"	661'
G	Tanker	35,000	35' 8"	661'
Company No. 4				
Vessel H	Tanker	28,900	29' 5"	492'
Company No. 5				
Vessel I	Passenger Ship	750 passengers	23'	682'

1/ Companies and vessel names have been replaced with a number and letter to avoid disclosure of confidential information.
2/ Does not include barge traffic. There are seven companies using barges to Hilo.

PROJECTION OF VESSEL TRAFFIC

A projection of ships by user for Piers 1, 2 and 3 at Hilo Harbor (Table H-13) was based on future incoming and outgoing tonnage through Hilo Harbor and on a two-year record of shipping trends available from the Department of Transportation, Harbors Division. A projection of vessels to each pier was made possible by obtaining the percentage split of cargo among users for that particular pier. A summary of all projected vessel and barge traffic through Hilo Harbor is shown on Table H-14. Based on conversations with various local shipping agencies, the existing scheduled trips by each company was assumed to remain constant as long as the capacity of the vessel was not exceeded. For example, in the year 1985, it is anticipated that Company No. 10's barge will handle approximately 52,292 short tons through Hilo Harbor. Based on its existing schedule of 24 trips per year and the capacity of this vessel, future shipments can be handled through the year 2010. In 2030, however, 120,717 short tons are estimated for the barge. With a barge capacity of only 30,000 barrels or 4,200 short tons, four additional trips will be needed to accommodate the anticipated petroleum shipments.

Table H-13 - Projection of Ships to Piers in Hilo Harbor by User

PIER 1

Year	Total Cargo to Pier (short tons)	Company No. 1 1/ — Vessel A2/ Total Cargo (short tons)	Trips	Company No. 1 1/ — Vessel B3/ Total Cargo (short tons)	Trips	Company No. 2 Total Cargo (short tons)	Trips	Company No. 3 Total Cargo (short tons)	Trips	Company No. 4 Total Cargo (short tons)	Trips
1985	315,500	117,262	26	117,262	52	170,000	15	30,975	20	50,000	3
1990	358,700	136,343	26	136,343	52	140,000	15	36,015	20	50,000	3
2000	429,200	167,480	26	167,480	52	139,000	15	44,240	20	50,000	3
2010	485,060	192,152	27 4/	192,152	52	138,000	15	50,757	20	50,000	3
2020	552,320	221,858	29 4/	221,858	52	137,000	15	58,604	20	50,000	3
2030	629,780	253,340	33 4/	228,800	52	136,000	15	67,641	20	50,000	3
2035	672,200	320,810	36 4/	228,800	52	136,000	15	72,590	20	50,000	3

PIER 2

Year	Total Cargo to Pier (short tons)	Company No. 5 Total Cargo (short tons)	Trips	Company No. 6 Total Cargo (short tons)	Trips
1985	177,000	13,275	12	163,725	156
1990	205,800	15,435	14	190,365	156
2000	252,800	18,960	17	233,840	156
2010	290,040	21,753	20	268,287	156
2020	334,880	25,116	23	309,764	156
2030	386,520	28,989	26	357,531	156
2035	414,800	31,110	28	383,690	156

Table H-13 (cont). Projection of Ships to Piers in Hilo Harbor by User

PIER 3

Year	Total Cargo to Pier (short tons)	Company No. 7 1/ Total Cargo (short tons)	Trips	Company No. 8 Total Cargo (short tons)	Trips	Company No. 9 Total Cargo (short tons)	Trips	Company No. 10 Total Cargo (short tons)	Trips	Company No. 11 Total Cargo (short tons)	Trips
1980	255,800	158,596	24	10,232	9	20,464	6	23,022	3	43,486	24
1985	307,600	190,712	24	12,304	10	24,608	8	27,684	3	52,292	24
1990	366,200	227,044	27	14,648	12	29,296	9	32,958	4	62,254	24
2000	485,500	301,010	35	19,420	16	38,840	12	43,695	5	82,535	24
2010	601,800	373,116	44	24,072	19	48,144	15	54,162	6	102,306	24
2020	710,100	440,262	51	28,404	23	56,808	17	63,909	7	120,717	28
2030	818,000	507,160	59	32,720	26	65,440	20	73,620	8	139,060	33
2035	865,000	536,300	63	34,600	28	69,200	21	77,850	9	147,050	35

1/ Company and vessel name has been replaced with a number and letter to avoid disclosure of confidential information.

2/ Vessel A will be making only 26 trips per year to Hilo. Any additional trips required for extra cargo will be handled by its sister ship. Vessel A currently carries 50% of its cargo to Kahului and the remaining 50% to Hilo.

3/ Vessel B will be making 52 trips per year to Hilo. Any residual cargo will be handled by an alternate vessel.

4/ Ship projections include the estimated number of trips to be made by the sister ship.

Table H-14. Summary of Future Vessel and Barge Trips to Hilo Harbor

Pier Year	Total Vessel and Barge Pier 1	Pier 2	Pier 3	Number of Vessels Per Trips to Hilo Harbor
1985	116	168	69	353
1990	116	170	76	362
2000	116	173	92	381
2010	117	176	108	401
2020	119	179	126	424
2030	123	182	146	451
2035	126	184	156	466

CALCULATION OF NAVIGATION BENEFITS

The calculation of benefits is based on vessel traffic and cargo volumes beginning in 1985, the base-year, and projected over the life of the project. The assumption was made that incremental savings result from the difference in transportation cost with the existing 35-foot harbor versus the proposed 38-foot depth.

Currently, there are only two vessels with fully loaded drafts that approach the existing project depths at Hilo Harbor. They are both bulk sugar vessels. The largest vessel, the Sugar Islander, is a 31,500 deadweight ton (DWT) vessel and has a maximum draft of 33 feet, 10 inches. The other, the Kopaa, is a 24,000 DWT vessel with a maximum draft of 33 feet, 8 inches. Over the 12 month period, October 1981 through September 1982, the two vessels made 26 trips between Hawaii and the West Coast hauling over 720,000 tons of raw sugar. Each trip a vessel called at one or more of the five major ports in Hawaii loading raw sugar at each stop. Table H-15 lists the dates and ports and tonnage for each vessel trip.

Table H-15. Vessel Trips Sugar Islander and Kopaa - October 1981 - September 1982

Vessel	Date	Port	Tonnage	Vessel	Date	Port	Tonnage
Sugar Islander	10-4	Hilo	16,393	Sugar Islander	5-16	Nawiliwili	7,998
	10-5	Honolulu	15,409		5-17	Honolulu	4,407
	10-6	Sailed	31,802		5-18	Kahului	9,259
					5-19	Kawaihae	7,694
Sugar Islander	10-24	Kahului	15,012		5-19	Sailed	29,358
	10-25	Nawiliwili	15,599				
	10-26	Sailed	30,621	Kopaa	5-21	Hilo	9,330
					5-24	Kawaihae	2,507
Sugar Islander	11-10	Honolulu	14,922		5-25	Kahului	8,008
	11-11	Nawiliwili	14,961		5-26	Honolulu	5,043
	11-12	Sailed	29,883		5-26	Sailed	24,888
Sugar Islander	11-30	Nawiliwili	29,519	Sugar Islander	6-8	Kawaihae	8,128
	12-2	Sailed	29,519		6-9	Kahului	16,063
					6-10	Honolulu	7,794
Sugar Islander	12-17	Hilo	30,735		6-11	Sailed	31,985
	12-19	Sailed	30,735				
				Kopaa	6-29	Hilo	12,037
Sugar Islander	1-4	Kawaihae	24,902		6-30	Kawaihae	12,184
	1-6	Hilo	4,358		7-1	Sailed	24,221
	1-6	Sailed	29,260				
				Sugar Islander	7-14	Kahului	30,328
Sugar Islander	2-5	Honolulu	13,683		7-17	Sailed	30,328
	2-6	Kahului	17,081				
	2-8	Sailed	30,764	Kopaa	7-16	Hilo	13,030
					7-18	Nawiliwili	9,904
Sugar Islander	2-23	Hilo	23,000		7-19	Sailed	22,934
	2-25	Kawaihae	8,317				
	2-26	Sailed	31,317	Sugar Islander	8-2	Kahului	30,767
					8-4	Sailed	30,767
Sugar Islander	3-15	Kahului	10,821				
	3-16	Hilo	18,340	Kopaa	8-3	Hilo	10,365
	3-17	Sailed	29,161		8-4	Kawaihae	13,896
					8-5	Sailed	24,261
Sugar Islander	4-2	Nawiliwili	16,055	Sugar Islander	8-19	Kawaihae	10,034
	4-4	Hilo	3,118		8-20	Kahului	20,665
	4-5	Kawaihae	10,461		8-22	Sailed	30,700
	4-6	Sailed	29,634				
				Kopaa	8-20	Hilo	13,949
Sugar Islander	4-23	Nawiliwili	7,459		8-21	Honolulu	10,195
	4-24	Kahului	5,023		8-22	Sailed	24,144
	4-25	Hilo	5,319				
	4-26	Kawaihae	8,317	Kopaa	9-7	Kahului	18,525
	4-27	Honolulu	4,449		9-8	Hilo	5,770
	4-27	Sailed	30,567		9-9	Sailed	24,295
Kopaa	5-3	Nawiliwili	6,840	Kopaa	9-23	Honolulu	10,195
	5-4	Kahului	3,577		9-24	Nawiliwili	11,663
	5-4	Hilo	4,295		9-25	Sailed	21,858
	5-5	Kawaihae	3,612				
	5-6	Honolulu	4,465				
	5-6	Sailed	22,789				

The Sugar Islander is the primary mover of sugar between Hawaii and the West Coast. As Table H-15 shows, the Sugar Islander made 17 of the total 26 vessel calls hauling 515,786 tons of raw sugar. The vessel called at Hilo, Kawaihae, Honolulu, and Nawiliwili 7 times and Kahului 9 times. The Kopaa is used sparingly and is put into service only when production levels are high, usually from April to November.

There are no established patterns for scheduling ports of call for the two sugar vessels. Officials indicate that an objective is to maintain an equal amount of available storage capacity at the port's sugar storage facilities. This will often require more frequent stops at one port than another, particularly when one island's yield is above average for the year. Generally, the sugar vessels proceed in one direction along the chain. The vessels do not backtrack between ports unless there are scheduling conflicts and a berth is not available. This occurs usually when a vessel unavoidably overstays its scheduled time in port because of repairs, adverse weather conditions or other circumstances. Table H-16 lists the number of vessel calls at each port and the number that were the first or last stop along the chain.

Table H-16. Vessel Calls - Hawaii Ports
October 1981 - September 1982

Port	Vessel Calls	First Stop	Last Stop
SUGAR ISLANDER			
Hilo	7	3	3
Kawaihae	7	3	3
Kahului	9	4	4
Honolulu	7	2	4
Nawiliwili	7	5	3
KOPAA			
Hilo	8	6	1
Kawaihae	4	0	2
Kahului	3	1	0
Honolulu	4	1	3
Nawiliwili	4	1	3
TOTAL			
Hilo	15	9	4
Kawaihae	11	3	7
Kahului	12	5	4
Honolulu	11	3	5
Nawiliwili	11	6	6

In November of 1982 the new Integrated Tug and Barge (ITB) will begin hauling raw sugar between Hawaii and the West Coast. The ITB is scheduled to make 16 to 17 trips to Hawaii a year. It will be the primary vessel for transporting sugar, hauling an estimated 576,000 tons a year. The Sugar Islander will transport the remaining tonnage of sugar with help from the Kopaa only when necessary. Under existing port conditions, the ITB will call at the various ports similar to the scheduled calls made by the Sugar Islander shown in Table H-16. As indicated, the ITB has 37,200 deadweight ton capacity, beam of 84 feet, length 684 feet, and a design draft of 36 feet. When filled to capacity with raw sugar the vessel is estimated to draft 34 feet.

The five major deep-draft ports in Hawaii have project depths of 35 feet at the sugar docks. Corps of Engineers regulations specify a minimum of 4.8 feet clearance under the keel for deep-draft vessels in Hawaii ports to insure safe and unrestricted navigation. This would limit vessel draft to about 30.2 feet. The Harbormaster, however, has allowed existing sugar vessels to navigate the harbors with deeper drafts under carefully controlled conditions and with the use of tides. Mean high tide in Hilo Harbor provides an additional 1.9 feet of channel depth. The vessel pilots have routinely taken advantage of the tide when departing fully loaded with sugar. In 1982, the Sugar Islander and Kopaa departed with 0.8 feet of tide on the average. The ITB is new to Hawaiian waters. Its dimensions push to the maximum the allowable limits for safe navigation in Hawaii's deep-draft ports. It is essential the 4.8 feet of underkeel clearance specified by standard COE design criteria be carefully adhered to for the ITB.

Restricted to a minimum of 4.8 feet clearance under the keel, the ITB cannot be loaded to full capacity with raw sugar under existing conditions. The proposed 38-foot project depth in Hilo Harbor plus an allowance of 0.8 feet for tide will permit the ITB to load to a maximum draft of 34 feet and maintain the required safe underkeel clearance of 4.8 feet. As indicated, the ITB will make vessel calls similar to the calls the Sugar Islander made shown in Table H-16. The ITB will call at Hilo seven times in a year. Three of the trips to Hilo will be the last port the vessel will load sugar before sailing to the West Coast. Company officials speculate, however, that with a 38-foot harbor at Hilo, routing schedules would be altered to allow the ITB to call at Hilo as a last stop as often as possible. Although careful coordination with the State would be needed to insure available berthing assignments, officials indicated that all seven calls at Hilo could be scheduled as last stops. They indicated that it would obviously be in their best interest to call at Hilo to top-off every vessel trip. However, taking into consideration the factors that influence the scheduling of ports of call, realistically only 10 last stops at Hilo to fully load to 34 feet could be scheduled.

Tables H-18, H-19, and H-20 provide data on vessel transportation costs fully loaded and at various shut-out drafts for the Kopaa, Sugar Islander and the new ITB. The advantage of traveling fully loaded is evident in the transportation cost per ton of cargo.

Navigation benefits for a deeper harbor were computed on the transportation savings per ton of cargo that would be realized by allowing the sugar vessels to navigate with unrestricted drafts greater than 31 feet (30.2 feet plus average of 0.8 feet of tide). Benefits were computed at 1-foot increments up to the maximum draft of 34 feet. It was assumed that all last stops at Hilo would be made by the ITB. Initially, seven last stops will be scheduled for Hilo after project completion. This is projected to increase at a minimum rate of one stop per year until 10 last stops are scheduled annually. For this analysis, one set of projections (Sugar Projection D, see Table H-17 and Figures H-2 - H-8) were used to compute total transportation costs with and without the project. Sugar Projection D represents the worst possible outlook for the sugar industry over the life of the project. The transportation cost savings computed using Sugar Projection D reflects a conservative assessment of future conditions and the minimum probable benefits of the proposed harbor project. It projects a continuous decline in production over the next 50 years. It is noted that if sugar production declines over the long haul, the Kopaa and Sugar Islander will be the vessels to first reduce and eventually eliminate calling at Hawaii's ports. Transportation cost savings computed on the ITB vessel trips would not be affected until total annual production dipped below 600,000 tons.

Table H-17. Projections of Raw Sugar Production by Counties Sugar Projection D 1/

Year	Hawaii	Kauai	Maui	Oahu	State
1985	315,000	225,000	265,000	162,000	967,000
1995	291,000	212,000	265,000	138,000	906,000
2005	291,000	200,000	265,000	112,000	868,000
2015	291,000	187,000	265,000	87,000	830,000
2025	291,000	173,000	265,000	61,000	790,000
2035	291,000	160,000	265,000	49,000	753,000

1/ Refer to page H-16 and Figures H-2 - H-8

Table H-18. Kopaa Transportation Costs, Full Load and Shut-Out Draft

Item	29'	30'	31'	32'	33'	34' (Full Load)
Port, Hilo ($)						
Wharfage 1/	10,500	11,050	11,600	12,150	12,700	13,250
Dockage 2/	688	703	721	739	756	774
Tug 3/	2,756	2,756	2,756	2,756	2,756	2,756
Pilot 4/	706	706	706	706	706	706
Linemen 5/	2,050	2,050	2,050	2,050	2,050	2,050
Port Entry	95	95	95	95	95	95
Ship ($)						
Hawaii Loading 6/	33,338	35,084	36,830	38,576	40,323	42,069
West Coast Discharging 7/	19,255	20,790	21,825	22,860	23,895	24,930
Travel Loaded 8/	289,600	289,600	289,600	289,600	289,600	289,600
Backhaul 8/	253,400	253,400	253,400	253,400	253,400	253,400
Port, West Coast ($)						
Wharfage 9/	4,725	4,973	5,220	5,468	5,715	5,963
Dockage	688	703	721	739	756	774
Tug	2,756	2,756	2,756	2,756	2,756	2,756
Pilot	706	706	706	706	706	706
Linemen	2,050	2,050	2,050	2,050	2,050	2,050
Port Entry						
Total Cost ($)	623,813	627,422	631,050	634,651	638,264	641,879
Payload (short tons) 10/	21,000	22,100	23,200	24,300	25,400	26,500
Cost Per Ton ($)	29.71	28.39	27.20	26.12	25.13	24.22

NOTE: Footnotes follow Table H-20.

Table H-19. Sugar Islander Transportation Costs, Full Load and Shut-Out Draft

Item	29'	30'	31'	32'	33'	34' (Full Load)
Port, Hilo ($)						
Wharfage 1/	13,600	14,100	14,600	15,100	15,600	16,100
Dockage 2/	686	711	736	761	787	812
Tug 3/	9,140	9,140	9,140	9,140	9,140	9,140
Pilot 4/	862	862	862	862	862	862
Linemen 5/	2,050	2,050	2,050	2,050	2,050	2,050
Port Entry	95	95	95	95	95	95
Ship ($)						
Hawaii Loading 6/	49,017	50,819	52,621	54,423	56,225	58,027
West Coast Discharging 7/	29,047	30,115	31,183	32,251	33,319	34,386
Travel Loaded 8/	244,200	244,200	244,200	244,200	244,200	244,200
Backhaul 8/	203,500	203,500	203,500	203,500	203,500	203,500
Port, West Coast ($)						
Wharfage 9/	6,120	6,345	6,570	6,795	7,020	7,245
Dockage	686	711	736	761	787	812
Tug	4,134	4,134	4,134	4,134	4,134	4,134
Pilot	862	862	862	862	862	862
Linemen	2,050	2,050	2,050	2,050	2,050	2,050
Port Entry						
Total Cost ($)	566,049	569,694	573,339	576,984	580,631	584,275
Payload (short tons) 10/	27,200	28,200	29,200	30,200	31,200	32,200
Cost Per Ton ($)	20.81	20.20	19.63	19.11	18.61	18.15

NOTE: Footnotes follow Table H-20.

Table H-20. ITB Transportation Costs, Full Load and Shut-Out Draft

Item	29'	30'	31'	32'	33'	34'	35'	36' (Full Load)
Port, Hilo ($)								
Wharfage 1/	15,750	16,400	17,050	17,750	18,400	19,050	19,700	20,350
Dockage 2/	794	827	860	895	928	960	993	1,026
Tug 3/	2,756	2,756	2,756	2,756	2,756	2,756	2,756	2,756
Pilot 4/	974	974	974	974	974	974	974	974
Linemen 5/	2,050	2,050	2,050	2,050	2,050	2,050		
Port Entry	95	95	95	95	95	95		
Ship ($)								
Hawaii Loading 6/	50,827	52,924	55,022	57,281	59,378	61,476	63,574	65,671
West Coast Discharging 7/	30,119	31,362	32,605	33,944	35,187	36,430	37,673	38,916
Travel Loaded 8/	223,500	223,500	223,500	223,500	223,500	223,500	223,500	223,500
Backhaul 8/	186,250	186,250	186,250	186,250	186,250	186,250	186,250	186,250
Port, West Coast ($)								
Wharfage 9/	7,088	7,380	7,673	7,988	8,280	8,573	8,865	9,158
Dockage	794	794	794	794	794	794	794	794
Tug	2,756	2,756	2,756	2,756	2,756	2,756	2,756	2,756
Pilot	974	974	974	974	974	974	974	974
Linemen	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050
Port Entry								
Total Cost ($)	526,777	531,092	535,409	540,057	544,372	548,688	553,004	557,320
Payload (short tons) 10/	31,500	32,800	34,100	35,500	36,800	38,100	39,400	40,700
Cost Per Ton ($)	16.72	16.19	15.70	15.21	14.79	14.40	14.04	13.69
Cost Per Ton ($) 11/	10.81	10.51	10.24	9.97	9.73	9.51	9.31	9.12

Footnotes for Tables H-18, H-19 and H-20.

1/ Wharfage fee based on $.50/ton for overseas shipment of bulk sugar ($.44/ton for interisland).

2/ Dockage fee based on $484 per day.

3/ When vessel enters port, one tug is needed for assistance. When vessel departs fully loaded two tugs are normally used. Since HT&T, which does the towing has only one tug, another tug from Maui is usually called. Cost for assist by HT&T tug is $1378 and $6384 for tug from Maui.

4/ Cost for one movement for 595' vessel, 641' vessel, and 688' vessel is $353, $431 and $487 respectively.

5/ Cost for one crew (6 men) working a minimum of 4 hours is approximately $42.73 x 6 x 4 = $1025.

6/ Based on a loading rate of 800 tons per hour at Hilo Harbor and a vessel operating cost in port of $30,500 per day for the 24,000 DWT vessel, $34,600 per day for the 31,500 DWT vessel, and $30,980 per day for the 37,000 DWT vessel.

7/ Based on discharge rate of 1350 tons per hour at Crockett, California.

8/ Based on a ship operating cost at sea of $36,200/day for the 24,000 DWT vessel, $40,700/day for the 31,500 DWT vessel, and $37,250/day for the 37,000 DWT vessel. The trip from Hilo to the West Coast will take approximately 8 days, 6 days, and 6 days, respectively. Backhaul will take 7, 5, and 5 days, respectively.

9/ Based on Honolulu Harbor Study. US West Coast wharfage costs assumed to be 45% of Hilo wharfage costs.

10/ Determined by linear regression analysis of actual cargo tonnage reported at various draft. This method was used to compensate for some inconsistencies in reporting data caused by miscellaneous tonnage (crew, supplies, equipment) and ballast.

11/ The ITB will backhaul fertilizer 4 trips a year. Fertilizer shipments will defray backhaul costs for those trips. The cost per ton figures were computed from total transportation costs less backhaul costs.

Annual transportation cost estimates were calculated for a 36, 37, and 38-foot harbor project at Hilo. The computed annual costs of each proposed project were compared with transportation costs with the existing 35-foot project depth. For illustration, Tables H-21 and H-22 compare transportation costs with and without a 38-foot harbor project at Hilo. The tables represent transportation data based on annual sugar production for the State given by Sugar Projection D in Table H-17. Similar computations were performed for the other project depths. A summary of undiscounted annual transportation cost savings of each of the project depths evaluated are shown in Table H-23. Table H-24 estimates the average annual equivalent savings--benefits.

Table H-21. Annual Transportation Cost Without Proposed 38-Foot Harbor at Hilo - Sugar Projection D 1/

Item	ITB		Sugar Islander	Kopaa
Capacity (tons)	34,100	34,100	29,200	23,200
Draft	31'	31'	31'	31'
Trips/yr	12	4 2/	5-13	3/
Cost/ton	$15.70	$10.24	$19.63	$27.20

Sugar Transported - Sugar Projection D

Year	ITB 12 Trips	ITB 4 Trips 2/	Sugar Islander 5-13 Trips	Kopaa 3/	Transported Sugar Projection D 4/
1985	409,200	136,400	373,400	0	919,000
1995	409,200	136,400	315,400	0	861,000
2005	409,200	136,400	279,400	0	825,000
2015	409,200	136,400	243,400	0	789,000
2025	409,200	136,400	205,400	0	751,000
2035	409,200	136,400	169,400	0	715,000

Annual Cost ($)

Year	ITB 12 Trips	ITB 4 Trips 2/	Sugar Islander 5-13 Trips 5/	Kopaa 3/ 6/	Transported Sugar Projection D 4/
1985	$6,424,440	$1,396,736	$7,329,842	0	$15,151,018
1995	6,424,440	1,396,736	6,191,302	0	14,012,478
2005	6,424,440	1,396,736	4,386,580	0	12,207,756
2015	6,424,440	1,396,736	3,821,380	0	11,642,556
2025	6,424,440	1,396,736	3,224,780	0	11,045,956
2035	6,424,440	1,396,736	2,659,580	0	10,480,756

1/ See Figure H-2.
2/ The ITB will backhaul fertilizer 4 trips a year; $10.81 equals the cost/ton computed without backhaul cost in Table H-18.
3/ Trips necessary to haul excess tonnage not able to be hauled by ITB and Sugar Islander.
4/ Ninety-five percent of total sugar production is shipped to the West Coast for refining. Five percent is processed on Oahu at the refinery in Aiea.
5/ Sugar Islander has an estimated remaining useful life of 20 years. It was assumed that by year 2005 it would be replaced by an ITB or similar vessel.
6/ Kopaa has an estimated remaining useful life of 10 years. It was assumed that excess sugar would be handled by a like vessel.

Table H-22. Annual Transportation Cost with Proposed 38-Foot Harbor at Hilo
Sugar Projection D 1/

Item		ITB		Sugar Islander	Kopaa
Capacity (tons)	38,100	34,100	34,100	29,200	23,200
Draft	34'	31'	31'	31'	31'
Trips/yr	7-10	2-5	4	4-12	3/
Cost/ton	$14.40	$15.70	$10.24 2/	$19.63	$27.20

Trips Per Vessel

Vessel	1985	1986	1987	1988-2035
ITB (34' Draft)	7	8	9	10
ITB (29' Draft)	5	4	3	2
ITB (29' Draft) 2/	4	4	4	4
Sugar Islander	12	12	11	4-11
Kopaa	0	0	0	0

Sugar Transportated - Sugar Projection D

Year	7-10 Trips	ITB 2-5 Trips	4 Trips 2/	Sugar Islander 4-12 Trips	Kopaa	Transported Sugar Projection D 4/
1985	266,700	170,500	136,400	345,400	0	919,000
1986	304,800	136,400	136,400	333,400	0	911,000
1987	342,900	102,300	136,400	325,400	0	907,000
1988	381,000	68,200	136,400	314,400	0	900,000
1995	381,000	68,200	136,400	275,400	0	861,000
2005	381,000	68,200	136,400	239,400	0	825,000
2015	381,000	68,200	136,400	203,400	0	789,000
2025	381,000	68,200	136,400	165,400	0	751,000
2035	381,000	68,200	136,400	129,400	0	715,000

Annual Cost ($)

Year	7-10 Trips	ITB 2-5 Trips	4 Trips 2/	Sugar Islander 4-12 Trips 5/	Kopaa 3/ 6/	Transported Sugar Projection D 4/
1985	$3,840,480	$2,676,850	$1,367,360	$6,780,202	0	$14,664,892
1986	4,389,120	2,141,480	1,367,360	6,544,642	0	14,442,602
1987	4,937,760	1,606,110	1,367,360	6,387,602	0	14,298,832
1988	5,486,400	1,070,740	1,367,360	6,171,672	0	14,096,172
1995	5,486,400	1,070,740	1,367,360	5,406,102	0	13,330,602
2005	5,486,400	1,070,740	1,367,360	3,758,580	0	11,683,080
2015	5,486,400	1,070,740	1,367,360	3,193,380	0	11,117,880
2025	5,486,400	1,070,740	1,367,360	2,596,780	0	10,521,280
2035	5,486,400	1,070,740	1,367,360	2,031,580	0	9,956,080

NOTE: Footnotes follow Table H-21.

Table H-23. Undiscounted Annual Transportation Cost Savings With a Deeper Harbor at Hilo - Sugar Projection D

PROJECT DEPTH	1985 ($)	1995 ($)	2005 ($)	2015 ($)	2025 ($)	2035 ($)
36 Feet	189,655	258,346	203,326	203,326	203,326	203,326
37 Feet	338,069	470,366	364,256	364,256	364,256	364,256
38 Feet	486,126	681,875	524,676	524,676	524,676	524,676

Table H-24. Average Annual Equivalent Benefits With a Deeper Harbor at Hilo - Sugar Projection D

	PROJECT DEPTH		
	36 Feet	37 Feet	38 Feet
Base Year Benefit	$189,655	$338,069	$486,126
Average Annual Equivalent Benefit 1/ 2/	$246,100	$436,900	$627,100

1/ Based on 50-year project life, 7-7/8% discount rate, and 1982 price levels.
2/ Transportation costs were evaluated from Tables H-21 and H-22. End of year discounting convention was used.

DAMAGE AND DELAY ANALYSIS

Problems Associated With Surge Conditions

Introduction. Although Hilo Harbor is presently protected by a breakwater, under certain weather conditions surge action creates a serious problem to navigation. At times when a heavy swell, unaccompanied by storms, is running from the north or northeast direction, waves or swells enter the harbor and are resolved into a marked surge within the bay at Piers 1, 2, and 3, causing ships to roll and pitch. It has been extremely difficult to hold rolling ships to the piers, which has delayed sailing, hampered efficient working of vessels and in several instances prevented complete discharge of cargo.

Frequency of Surge Conditions. To establish the total monetary losses resulting from the above conditions and to determine the prospective benefits which may be expected to accrue from improvements to Hilo Harbor, it was first necessary to compile from available sources the record of past surge conditions and the number of vessels adversely affected. From data obtained from past reports and from the files and daily log reports of the Hilo Harbormaster, the following record of surge conditions was compiled.

Table H-25. Record of Surge Condition

Year or Period	Heavy Surge Conditions Reported (Number of Days)	Total Number of Vessels Adversely Affected
1934-1938 (inclusive)	36	32
1940	5	5
1946	4	4
1947	6	9
1950-1960 (inclusive)	25	32
1961-1969	190	70
1977-1979	9	7
Total for 31 Years	275	159
Annual Average	8.9	5.1

It has been estimated that approximately 9 days of heavy surge action may be expected each year with over 87 percent occurring from October to March. Earlier estimates (1930-1970) computed from the above record covered only surge conditions when vessels were adversely affected. The remaining estimates of surge conditions (only 1977-1979) were counted for heavy surge regardless of whether there were any vessels in the harbor or whether a vessel was subject to surge action. The relatively high incidence of reported surge conditions prior to the period beginning with 1950 reflects to a major extent interisland steamer vessels adversely affected. Since 1952, interisland steamer operations have been discontinued. Waterborne interisland commerce is now handled exclusively by tugs and barges, containerships and a few tankers. Historical records on surge conditions have been very erratic. There is no distinct trend from which to approximate future conditions. An inspection of the available data indicates that the occurrence of heavy surge may be a cyclical condition. Between 1960 and 1970, an extremely high number of heavy surge occurrences was experienced; however, after 1970, a significant drop in surge was noted. It is further noted that in 1970, the State implemented non-structural measures to reduce surge related damages and delays. The measures included: close monitoring of the surge problem by the Harbormaster and weather bureau; last minute rescheduling or rerouting vessels departing or en route to Hilo; and tying off vessels to a mooring buoy located in center of the harbor. Interviews with ship captains, harbor and shipping company officials concluded that these non-structural measures have effectively reduced surge related damages and delays by about 50 percent.

Record of Past Damages and Delays. For the determination of average annual damages associated with surge conditions at Hilo Harbor over the past years of record, the period from 1934 to 1980 was selected for detailed study. Although several years of records are missing, an appraisal of the entire record revealed that the coverage of surge conditions and vessels affected during the 31 years recorded was fairly complete. Further, the information relative to vessel action during surge disclosed in the record for this period provided a reliable basis for the estimation of monetary damages and losses. A detailed analysis of total monetary damages and losses was completed for the period between 1934-1980. The types of damages or losses associated with vessels affected by surge generally fall into three categories. First, there are the delay costs for a vessel required to remain in the harbor for extended periods over and above the normal period of time required to work a given vessel. A detailed delay analysis was conducted using historical data and a 31-year record of surge at Hilo Harbor. Secondly, there are associated stevedoring delay costs. These costs take the form of stevedore standby time and efficiency losses incurred in working vessels subject to surge action. In those cases where delays were incurred after a vessel had discharged and loaded cargo, no stevedore delay costs were taken. A third category of monetary losses includes the cost of emergency measures such as anchoring, moving the vessel within the harbor, and the cost of running additional mooring lines to hold vessels. There are also the costs associated with the loss of lines and hawsers, as well as actual damages to the affected vessels and to the port facilities. Typical damages to port facilities over the years have been damages to the pier fender system. Because of the differences in the techniques of reporting for this period, monetary losses for certain years have been estimated as a lump sum at the end of the detailed tabulation. In both cases the detailed damage estimates were increased 10 percent as a conservative estimate of monetary losses to vessels not covered in the reports of surge conditions. All monetary losses are expressed in terms of constant price levels.

Benefits from Reduction of Surge

A plan of improvement could reduce surge conditions within the bay and at the piers to non-damaging proportions. The benefits presented estimate existing and future annual delays and damages that could be reduced with a plan of improvement. To determine the average annual benefits which may be expected to accrue from improvements to Hilo Harbor over the 50-year economic life of the project, it was necessary to first establish the preventable delays and damages under existing harbor conditions and utilization. Secondly, the accrual of future delays and damages were estimated that would occur without the improvements.

Vessel Delays. The estimate of total delay costs of $568,745 for the recorded 29-year period for which delay costs could be computed, or $20,000 annually was used as a comparison for future delay cost projections. Future delay costs are directly related to the number of vessel trips through Hilo Harbor. Between 1948 and 1958, the average number of vessels through Hilo Harbor was 240. From 1985-2035 it is anticipated that vessel traffic will grow from 353 to 466 vessels annually.

Projection of Vessel Delays. Based on historical records, the probability of heavy surge occurrences at Hilo Harbor was calculated. Combining this information with the projected number of vessel trips to Hilo Harbor and the average surge delay time for each vessel type gives the annual delay time encountered in port by a vessel during heavy surge conditions. To arrive at the total annual delay cost, the hourly delays due to surge conditions was multiplied by the vessel operating cost. Table H-26 gives a breakdown of the various vessels anticipated to experience delay costs. Based on an interest rate of 7-5/8% and a 50-year period of analysis, the equivalent average annual delay costs that could be prevented with a plan of improvement was computed to be $130,095.

Stevedore Delays. Because of surge conditions in Hilo Harbor, stevedore delays are also occasionally encountered. When surge conditions are severe, vessels are unable to enter or unload at the docks. Most companies charge a minimum of 5 hours for an idle stevedore crew, but a company with its own stevedores charges a minimum of 4 hours. No stevedore costs are incurred with vessels transporting petroleum or petroleum products to Hilo. Workmen aboard these vessels are paid their regular hourly wages regardless of whether any delays are encountered. These delay costs have been included in the vessel delay costs computations. The stevedore delay costs are computed by taking the number of vessel trips affected by surge each year and multiplying this number by the minimum standby cost for various stevedore crews. It was assumed that no delays would be experienced after unloading operations. A summary breakdown of the stevedoring delay costs at Hilo Harbor is shown for each major vessel in Table H-27.

Damages Under Existing Conditions. Total damages of $733,900 from severe surge conditions occurred from 1934-1938, 1952-1969, and 1977-1979 at Hilo Harbor. To establish a realistic annual damage estimate under existing conditions as a base for future damage projections, it was necessary to modify the total damage estimate for a segment of past traffic not expected to continue in the future and for surge reduction measures implemented by the State. Thus, only those damages occurring from 1952-1969 and 1977-1979 were used for projecting future surge related damages. The adjusted total damage estimate is then $697,200, or $26,815 annually.

Table H-26. Projected Average Annual Vessel Delay Cost for Hilo Harbor 1/2/

Vessel	1980	1985	1990	2000	2010	2020	2030	2035	Surge Delay (Hrs) 3/
A--# yearly trips		52	52	52	52	52	52	52	21
$ loss due to surge @ $442/hr		11901	11901	11901	11901	11901	11901	11901	
B--# yearly trips		26	26	26	27	29	33	36	21
$ loss due to surge @ $1445/hr		19454	19454	19454	20202	21699	24692	26936	
C--# yearly trips		156	156	156	156	156	156	156	21
$ loss due to surge @ $1124/4 hrs		22699	22699	22699	22699	22699	22699	22699	
D--# yearly trips		20	20	20	20	20	20	20	21
$ loss due to surge @ $1124/4 hrs		2910	2910	2910	2910	2910	2910	2910	
E--# yearly trips	3	3	4	5	6	7	8	9	21
$ loss due to surge @ $2208/hr	3430	3430	4573	5717	6860	8003	9147	10290	
F--# yearly trips	24	24	27	35	44	51	59	63	21
$ loss due to surge @ $1124/4 hrs	3492	3492	3929	5093	6402	7421	8585	9167	
G--# yearly trips	24	24	24	24	24	28	33	35	21
$ loss due to surge @ $370/hr	4598	4598	4598	4598	4598	5364	6322	6706	
H--# yearly trips	6	6	6	6	6	6	6	6	21
$ loss due to surge @ $1290/hr	4008	4008	4008	4008	4008	4008	4008	4008	
I--# yearly trips	4	4	4	4	4	4	4	4	21
$ loss due to surge @ $1442/hr	2987	2987	2987	2987	2987	2987	2987	2987	
J--# yearly trips	52	52	52	52	52	52	52	52	21
$ loss due to surge @ $1410/hr	37966	37966	37966	37966	37966	37966	37966	37966	
K--# yearly trips	9	10	12	16	19	20	26	28	21
$ loss due to surge @ $509/hr	2372	2636	3163	4217	5008	5271	6853	7380	

Table H-26 (cont). Projected Average Annual Vessel Delay Cost for Hilo Harbor 1/2/

Vessel	1980	1985	1990	2000	2010	2020	2030	2035	Surge Delay (Hrs) 3/
L--# yearly trips	6	8	9	12	15	17	20	21	21
$ loss due to surge @ $370/hr	1149	1533	1724	2299	2874	3257	3832	4023	
M--# yearly trips		3	3	3	3	3	3	3	21
$ loss due to surge @ $1290/hr		2004	2004	2004	2004	2004	2004	2004	
N--# yearly trips		12	14	17	20	23	26	28	21
$ loss due to surge @ $268/hr		1665	1943	3090	2775	3192	3608	3886	
O--# yearly trips		3	3	3	3	3	3	3	21
$ loss due to surge @ $1290/hr		2004	2004	2004	2004	2004	2004	2004	
YEARLY TOTALS		123287	125287	130947	135198	142686	149518	154867	

AVERAGE ANNUAL = $130,095

1/ Vessel name has been replaced with a letter to avoid disclosure of confidential information.
2/ Vessel delay cost computed using following equation:

$$\text{Delay Cost} = \frac{\text{ave. \# days of heavy surge}}{365} \text{(trips/yr) (surge delay time in hrs/trip) (operating cost/hr)}$$

3/ Based on historical record of severe surge conditions encountered in Hilo Harbor.

Table H-27. Projected Avarage Annual Stevedore Delay Cost for Hilo Harbor 1/2/

Vessel 1/	1985	1990	2000	2010	2020	2030	2035	Delay Avg (Hr) 3/
A--# trips/yr	52	52	52	52	52	52	52	5
$ loss due to stevedoring delay @ 225/hr	1442	1442	1442	1442	1442	1442	1442	
B--# trips/yr	26	26	26	27	29	33	36	5
$ loss @ 1000/hr	3205	3205	3205	3329	3575	4068	4438	
C--# trips/yr	6	6	6	6	6	6	6	5
$ loss @ 400/hr	296	296	296	296	296	296	296	
D--# trips/yr	4	4	4	4	4	4	4	5
$ loss @ 400/hr	197	197	197	197	197	197	197	
E--# trips/yr	156	156	156	156	156	156	156	4
$ loss @ 150/hr	2308	2308	2308	2308	2308	2308	2308	
F--# trips/yr	20	20	20	20	20	20	20	5
$ loss @ 250/hr	616	616	616	616	616	616	616	
G--# trips/yr	52	52	52	52	52	52	52	5
$ loss @ 180/hr	1154	1154	1154	1154	1154	1154	1154	
Yearly Totals	9218	9218	9218	9342	9588	10081	10451	

Equivalent Average Annual Cost - $9,290

1/ Vessel name has been replaced with a letter to avoid disclosure of confidential information.

2/ Stevedore delay cost computed using following equation:

$$\text{Delay Cost} = \frac{\text{ave. \# days of heavy surge}}{365}\text{(trips/yr)(ave. hrs. delay/trip)(crew cost/hr)}$$

3/ Minimum time charged for stevedore delay.

Projection of Damages. The annual estimate of $26,815 represents the average annual preventable damages for the period from 1952-1979 and serves as a basis for the projection of future benefits over the economic life of the proposed improvements. Future benefits associated with the elimination of adverse surge conditions were based on the number of transpacific and interisland vessels expected to call on Hilo Harbor over the next 50 years. Projections of vessel traffic were presented earlier and are summarized below.

Table H-28. Calculations for Projected Total Damage Costs

Year	Number of Transpacific & Interisland Vessels Through Hilo Harbor	Percent Increase Over Previous Period
1962-1977 (annual average)	395	
1985	338	-14.4
1990	347	2.7
2000	366	5.5
2010	386	5.5
2020	409	6.0
2030	436	6.6
2035	451	3.4

Assuming that future benefits will accrue in direct proportion to the expected increases in vessel traffic, future levels of benefit accrual were established as follows.

Table H-29. Damage Benefits

Year	Estimated Annual Damage Benefits 1/
1979 (existing condition)	$26,815
1985	22,954
1990	23,574
2000	24,870
2010	26,238
2020	27,812
2030	29,648
2035	30,656

Equivalent Average Annual = $24,332 1/

1/ Based on 1985 base year.

As noted earlier, the basic damage estimate includes not only vessel damage associated with transpacific vessel traffic, but also damage allowances for interisland barge traffic as well. In estimating future benefits, it was assumed that the rate of increase in transpacific traffic used as a basis for projection was of sufficient magnitude to account for benefits to interisland vessels. Based on the projection of future average annual benefits, the equivalent average annual benefit associated with the elimination of adverse surge condition damages at Hilo Harbor was computed to be $24,300 at an amortization rate of 7-5/8%.

Summary of Surge Reduction Benefits. Total average annual benefits to reduce surge conditions at Hilo Harbor consist of benefits from reduction in vessel and stevedore delays and vessel and pier facility damages. A summary of these benefits is shown below.

Table H-30. Summary of Potential Surge Reduction Benefits

Category	Total	With Existing Non-Structural Measures 1/
Vessel Delay Costs	$130,095	$65,000
Stevedore Delay Costs	9,300	4,650
Vessel and Pier Facility Damage	24,300	12,150
	$163,695	$81,800

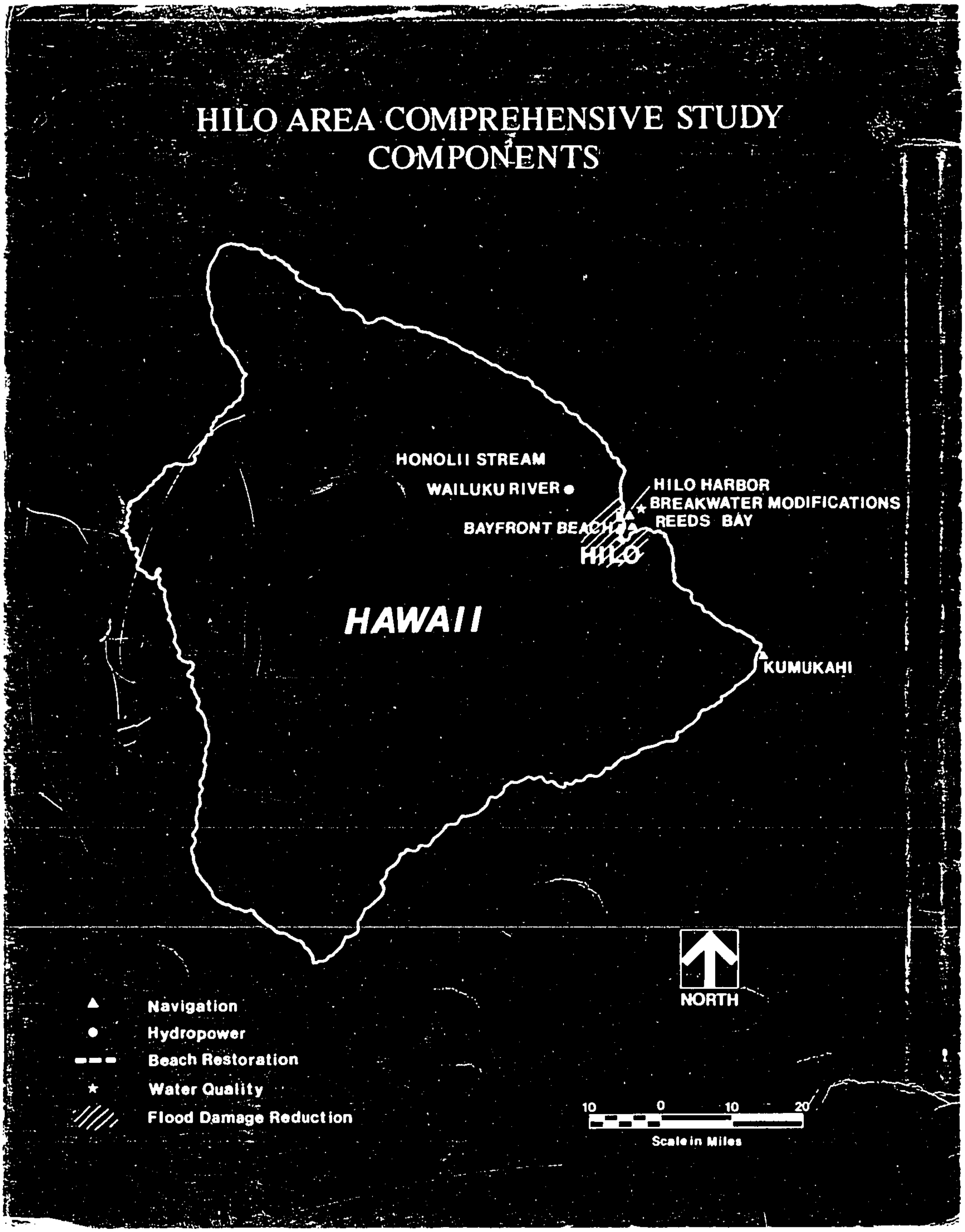
1/ Existing State implemented non-structural measures have reduced surge related delay costs and damages by 50 percent.

Submersible Buoy

Located near the center of the turning basin is a fixed mooring buoy used exclusively for holding vessels off Pier 1 during surge conditions. The buoy is used in lieu of anchoring vessels in Hilo Bay. The fixed structure is estimated to reduce vessel and pier facility damages 50 percent or $12,150 annually. In addition, about $13,800 is estimated to be saved annually in additional vessel operating costs that would be incurred if vessels had to relocate to anchorages in Hilo Bay and later return to Pier 1.

The fixed buoy, however, is inappropriately placed within the limits of a Federal project. The buoy is considered somewhat of a hazard to navigation that interferes with the free and unrestricted use of the turning basin. From a navigation standpoint it should be removed. However, without the fixed buoy heavy surge condition delays and damages would again increase to those historical levels before the buoy was installed. The most engineeringly feasible alternative to reduce surge damages and delays assuming the existing fixed buoy is removed is the proposed submersible mooring buoy. The submersible buoy would provide the same monetary benefits for reduction in damages and vessel operating delay costs as the fixed structure. When not in use, the submersible buoy would enhance free and unrestricted use of the Federally maintained turning basin.

The submersible buoy is the least costly alternative for providing protection against surging in Hilo Bay. It will protect against surging at Pier 1 where damages to vessels and pier almost exclusively occur. The average annual net benefits of the submersible mooring buoy are estimated to be $25,950.


HILO AREA COMPREHENSIVE STUDY
COMPONENTS
HONOLII STREAM
WAILUKU RIVER
HILO HARBOR
BREAKWATER MODIFICATIONS
REEDS BAY
BAYFRONT BEACH
HILO
HAWAII
KUMUKAHI
NORTH
Navigation
Hydropower
Beach Restoration
Water Quality
Flood Damage Reduction
10
0
10
20
Scale in Miles